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Applicant KATZ, Marcos	

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1. The following indications appeared on record concerning:

[ ] the applicant [ ] the inventor [X] the agent [ ] the common representative

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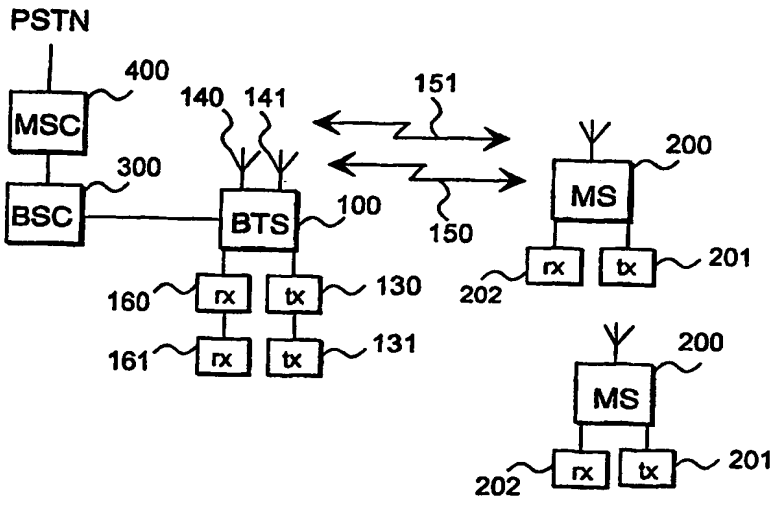

(57) Abstract

The invention relates to a data transmission method and a radio system comprising at least one subscriber terminal (200) and at least one base station (100) comprising an antenna (140, 141), by means of which the base station transmits signals to the subscriber terminal. The subscriber terminal (200) comprises a measuring means (230) which determines the quality of the signals received by the subscriber terminal by comparing the received signals with at least one signal quality threshold level. When only one signal exceeds the threshold, the subscriber terminal (200) sends to the base station (100), which transmitted the signal that exceeded the threshold, a command to use, when transmitting a signal to said subscriber terminal, the antenna with which the signal that exceeded the threshold was transmitted, or the transmission direction to which the signal that exceeded the threshold was transmitted.

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DATA TRANSMISSION METHOD AND RADIO SYSTEM

FIELD OF THE INVENTION

The invention relates to a data transmission method used in a radio system comprising a subscriber terminal and at least one base station transmitting signals to the subscriber terminal by means of its antenna.

BACKGROUND OF THE INVENTION

In transmitting signals, prior art radio systems use various diversity methods to improve the quality of data transmission. Diversity methods include, for instance, orthogonal transmit diversity (OTD), time switching transmit diversity (TSTD) and selective transmit diversity (STD). The above-mentioned diversity methods can be used in future WCDMA systems, for instance. Said methods improve BER performance, for instance, in data transmission. Of the above-mentioned methods, especially the STD method provides the greatest advantages as compared with the OTD and TSTD methods, for instance.

In FDD systems, the STD method can be used in selecting antennas, for instance. In this case, in a radio system, a subscriber terminal, which can be a mobile phone, for instance, selects and advises the base station to select an as optimal antenna as possible for the base station to use in a downlink signal transmission. The selection of antennas is based on measuring the quality of signals transmitted by the base station antennas and comparing the obtained measurement results with each other.

However, the use of STD methods causes load problems in the power amplifiers of the transceiver. The problems are caused because the load of the power amplifiers is not always distributed evenly between the various power amplifiers, and the differences in loads may be relatively big. In a CDMA-type radio system, for instance, a situation may arise in practice where a given transmission branch of a base station is selected to transmit signals to a large number of subscriber terminals which establish simultaneous connections by means of the signals. Such a selection method calls for extensive dynamics of the power amplifier at the transmission branch. Extensive dynamics call for using a high crest coefficient in designing the power amplifiers, which coefficient is determined by the ratio of the maximum output required of the power amplifier and its average output.

Let us assume that the base station comprises a first and a second

transmission antenna which transmit a signal to the same subscriber terminal. Let us further assume that the base station comprises a first power amplifier feeding its signal to the first transmission antenna and a second power amplifier feeding its signal to the second transmission antenna. If the subscriber terminal is advantageously located with respect to the first transmission antenna, for instance, the subscriber terminal receives a signal of at least slightly better quality from the first transmission antenna. In practice, it may well be possible that the signal transmitted by the second antenna is also received as a relatively good-quality signal. If the antenna is selected to transmit a signal to mobile phones, of which there are K and to each of which the base station power amplifier transmits the signal at P power, the dynamics of the base station power amplifier must achieve a power level of at least KP.

Because the selection of antennas is based solely on measuring the absolute quality of the signal, the subscriber terminal sends to the base station a command to use the first transmission antenna. If sufficiently many subscriber terminals command the base station to use the first transmission antenna, it is possible that the nominal loadability of the first power amplifier is exceeded. If the subscriber terminal has had to select the better of two base station antennas, for instance, the subscriber terminal can transmit information on the selection by using one selection bit. In the above-mentioned situation, the value of the selection bit may be '1', for instance, indicating the selection of the first transmission antenna, for instance. The value '0' of the selection bit would then have indicated the selection of the second transmission antenna.

The selection method is, however, not optimal from the point of view of the power amplifier load, since the used method may lead to overload in the power amplifier feeding the selected transmission antenna. The load of the power amplifiers is thus too uneven in some situations. Said problems are at least partly caused by the fact that measuring the signal quality is based on absolute values which does not lead to the best possible solution for the operation of the system.

BRIEF DESCRIPTION OF THE INVENTION

The object of the invention is thus to implement a method and an apparatus implementing the method in such a manner that the above-mentioned problems can be solved. This object is achieved by a data transmission method as described in the specification, characterized by

determining the quality of the signals received by the subscriber terminal by comparing the received signals with at least one signal quality threshold level, sending to the base station, which transmitted the signal that exceeded the threshold, information on the antennas which transmitted the signals that exceeded the threshold, or information on the transmission direction, from which the signal that exceeded the threshold was received, selecting from the antennas, which transmitted the signal that exceeded the threshold, an antenna or antennas to continue the transmission of the signal to said subscriber terminal, or selecting from the transmission directions, from which the signal that exceeded the threshold was received, a transmission direction or directions, to which to continue the transmission of the signal to said subscriber terminal.

In addition, the object is achieved by a data transmission method as described in the specification, characterized by determining the quality of the signals received by the subscriber terminal by comparing the received signals with at least one signal quality threshold level, and when only one signal exceeds the threshold, sending to the base station which transmitted the signal that exceeded the threshold a command to use, when transmitting a signal to said subscriber terminal, the antenna with which the signal that exceeded the threshold was transmitted, or the transmission direction to which the signal that exceeded the threshold was transmitted.

The invention also relates to a radio system comprising at least one subscriber terminal and at least one base station comprising an antenna with which the base station transmits signals to the subscriber terminal.

The radio system of the invention is characterized in that the subscriber terminal comprises a measuring means which determines the quality of the signals received by the subscriber terminal by comparing the received signals with at least one signal quality threshold level, the subscriber terminal sends to the base station, which transmitted the signal that exceeded the threshold, information on the antennas from which the signal that exceeded the threshold was transmitted, or information on the transmission directions from which the signal that exceeded the threshold was received, the base station comprises a means which selects from the antennas, which transmitted the signals that exceeded the threshold, an antenna or antennas which continue to transmit a signal to said subscriber terminal, or the means selects from the transmission directions of the signals, which exceeded the

threshold, a transmission direction or directions to which the base station continues to transmit a signal.

In addition, the radio system of the invention is characterized in that the subscriber terminal comprises a measuring means which determines the quality of the signals received by the subscriber terminal by comparing the received signal with at least one signal quality threshold level, and when only one signal exceeds the threshold, the subscriber terminal sends to the base station, which transmitted the signal that exceeded the threshold, a command to use, when transmitting a signal to said subscriber terminal, the antenna with which the base station transmitted the signal that exceeded the threshold, or the transmission direction to which the signal that exceeded the threshold was transmitted.

The preferred embodiments of the invention are disclosed in the dependent claims.

The invention is based on the idea that the subscriber terminal measures the signals transmitted by the base station by comparing them to a threshold level, and the transmission antenna, transmission direction or beam used by the base station is selected case by case either in the subscriber terminal or base station.

The data transmission method and radio system of the invention provide several advantages. With the method of the invention, the load of the amplifiers in the base station of the radio system can continuously be distributed as evenly as possible between each amplifier. Since the load remains even, the dynamics of the amplifiers need not be as extensive as in amplifiers used in prior art radio systems, thus facilitating the design of amplifiers.

The method minimizes the unevenness of load between power amplifiers by letting the base station select the transmission antenna of a downlink transmission, when necessary. If the base station uses adaptive antennas, the method of the invention makes it possible to select a transmission direction which causes as little interference as possible to the other signals in the radio network.

In addition, the method makes it possible to implement a flexibly operating radio system. In a receiver, which is a subscriber terminal, of the radio system of the invention, the received signals are categorized by means of threshold levels into different signal groups. Using several thresholds makes

it possible to allocate channels more flexibly to receivers. In addition, using thresholds improves the reliability of the antenna selection. The solution of the invention is relatively easy to implement by altering signalling, for instance.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in greater detail by means of preferred embodiments with reference to the attached drawings, in which

Figure 1 shows a radio system of the invention,

Figure 2 shows the structure of a base station of the radio system,

Figure 3 shows a more detailed description of the base station,

Figure 4 shows the structure of a subscriber terminal in the radio system,

Figure 5 illustrates the purpose of use of the threshold levels,

Figure 6 illustrates the selection process used in the radio system.

DETAILED DESCRIPTION OF THE INVENTION

Figure 1 shows a radio system comprising a base station 100, subscriber terminals 200, a base station controller 300 and a mobile switching centre 400. The subscriber terminals 200 can be mobile phones, for instance. The base station comprises transmitters 130, 131 and receivers 160, 161. In addition, the base station comprises antennas 140, 141 with which the base station transmits and receives signals. The base station transmits to a subscriber terminal and receives from a subscriber terminal a signal 150 by means of its antenna 140. In addition, the base station transmits to a subscriber terminal and receives from a subscriber terminal a signal 151 by means of its antenna 141. The figure shows that the subscriber terminal comprises a transmitter 201 and a receiver 202. The subscriber terminal can receive signals transmitted from the various antennas of the base station. The signals containing the same information received by the subscriber terminal can also be transmitted by different base stations.

Figure 2 shows in greater detail the structure of the base station 100 in the radio system of the invention. The base station comprises antennas 140, 141 acting in practice as transceiver antennas. In addition, the base station comprises an amplifier 111, a radio frequency part 112, a demodulator 113 and a decoder 114 on the receiving side. The base station can use antenna diversity, for instance, in transmission. The antennas must be located far enough from each other when using antenna diversity. The distance of the

antennas can be at least 10 to 20fold, for instance, in relation to the used wavelength.

The antennas can also be adaptive antennas, for instance, in which case they allow the use of angle diversity in transmitting signals. The base station forms beams with the adaptive antennas to use in transmitting signals. The adaptive antennas are located at a distance of at most half of the used wavelength, for instance, in relation to each other.

The radio-frequency signal received by the base station is forwarded from the antenna to the amplifier 111 which amplifies the level of the received signal. The amplified signal is forwarded to the radio frequency part 112 which transfers the signal to an intermediate frequency. The radio frequency part 112 is connected to the demodulator 113 which returns the broadband signal to a narrowband data signal, if the signal in question is a CDMA signal. The invention is, however, not in any way restricted to the CDMA system, and the system can, for instance, be a TDMA system or a radio system operating according to another principle.

The data signal is forwarded from the demodulator 112 to the decoder 114 which decodes the data signal in a suitable manner. The signal coming in to the decoder 114 can be convolution-coded, for instance. The operation of the decoder 114 can be based on the Viterbi algorithm, for instance. Typically, the decoder 114 decrypts and deinterleaves the signal.

On the transmission side, the base station comprises an amplifier 121, a coder 122, a modulator 123 and a radio frequency part 124. The coder 122 receives a signal and, after coding it, transmits the signal to the modulator 123. The coder 122 can use convolution coding, for instance. In addition, the coder 122 encrypts the signal, for instance. The coder 122 also interleaves the signal bits or bit groups. In practice, the modulator 123 can act as a symbol modulator, for instance. If the transceiver is of CDMA type, the signal received from the modulator 123 is pseudo-random noise-coded into a broadband spread-spectrum signal. After this, the spread-spectrum signal is converted into radio frequency according to prior art in the radio frequency part 124. The radio-frequency signal is forwarded to the amplifier 121 which amplifies the signal. The amplified signal is transmitted via the antenna to the radio path. The base station also comprises a means 102 which controls the operation of the above-mentioned base station blocks, and a means 103 which stores data

on the load status of the amplifiers, for instance. The means 103 can be implemented with a memory circuit, for instance.

In practice, the receiving side of the base station comprises several receiver branches. Correspondingly, the transmitting side of the base station may comprise several transmitter branches and each transmitter branch can be connected to its own antenna, for instance. In addition, the signals going through each transmitter branch are typically forwarded to different amplifiers for amplification. Figure 3 illustrates the above-mentioned base station which has several amplifiers acting as power amplifiers on the transmitting side.

Figure 4 shows in greater detail the structure of the subscriber terminal used in the radio system of the invention. The subscriber terminal comprises an antenna 240, an amplifier 211, a radio frequency part 212, a demodulator 213, a decoder 214, an amplifier 221, a coder 222, a modulator 223 and a radio frequency part 224, an amplifier 221 and a control means 202. In principle, the above-mentioned subscriber terminal parts function in the same way as the parts corresponding to said parts in the base station. In addition, the subscriber terminal comprises a measuring means 230 which measures the quality of the signals received by the subscriber terminal. Measuring the quality can be based on measuring signal strength, amplitude-to-power ratio, S/N ratio, signal energy or signal bit error ratio, for instance. The measuring means can measure the signal quality continuously or periodically.

The subscriber terminal can simultaneously receive signals from either the same base station or from several base stations. The measuring means 230 in the subscriber terminal measures the received signals. The purpose for measuring the signal quality is to select the most optimal antenna for the radio system to transmit the signal to the subscriber terminal. The transmission direction or the beam used in transmission can also be selected on the basis of the signal quality measurement. The base station can use the load situation of an amplifier, for instance, as a selection criterion. Another purpose is that the final selection decision on the transmission antenna, transmission direction and/or amplifier is made either in the subscriber terminal or the base station.

The measuring means 230 compares the measured signal with one or more threshold levels. Figure 5 shows a diagram illustrating the purpose of use of the threshold levels used in the subscriber terminal. Let us assume that

the subscriber terminal receives a signal 150 transmitted by an antenna 140, and a signal 151 transmitted by an antenna 141. There is at least one threshold level for the received signals, with which the signal quality is compared. The threshold levels can be pre-set at fixed values, for instance. In measuring the received signal, the placement of the signal being measured is examined in relation to the threshold level. The signal being measured can be either below or above the threshold level. In some special cases, the signal being measured may be at exactly the threshold level. In the radio system of the invention, a method known as the B-STD diversity method (Balanced Selective Transmit Algorithm) is used to help select the transmission antenna and transmission direction of the base station. The signals of different antennas or beams can be distinguished from each other in the subscriber terminal on the basis of different codes, their pilot signal or training sequence code.

Let us assume that in Figure 5, the subscriber terminal receives a signal S1 and S2. Let us further assume that the base station antenna 140 transmits the signal S1 and the antenna 141 transmits the signal S2. When the quality of both signals exceeds the pre-set level Th, the subscriber terminal sends information on the quality of the signals to the base station, and consequently, either the antenna 140 which transmitted the signal S1 or the antenna 141 which transmitted the signal S2 can be selected as the final transmission antenna. In the above situation, both antennas 140, 141 can be selected as final transmission antennas. The same principle can also be used when selecting the beam or the transmission direction. In the situation described above, the base station makes the final decision on the transmission antenna, transmission beam or transmission direction on the basis of the information sent by the subscriber terminal. In practice, the means 102 in the base station makes the decision.

If the signal S1 exceeds the threshold, but the signal S2 is below it, the subscriber terminal sends information on the quality of the signals to the base station. After receiving the information, the base station continues to transmit the signal S1 through the antenna 140. If the signal S1 is below the threshold, but the signal S2 exceeds it, the subscriber terminal sends information on the quality of the signals to the base station, and having received it, the base station continues to transmit the signal S2 through

antenna 140. In the above-mentioned situations, the final decision on the transmission antenna, for instance, is already made in the subscriber terminal.

If both signals S1, S2 are below the threshold level, the subscriber terminal sends information on the quality of the signals to the base station which can, for instance, stop transmitting both signals. Therefore, the setting of the threshold level has a high significance. The threshold level can be set to a level, for instance, that when the signal received by the subscriber terminal is below it, the base station antenna which transmitted the signal will not be taken into consideration in the selection process. However, when the quality of the signal received by the subscriber terminal is above the threshold level, the base station antenna which transmitted the signal is considered in the selection process. In the case described above, the subscriber terminal can send the information on the signal quality or antenna selection in one bit. If the subscriber terminal receives signals with M antennas, M bits are required to send all above-mentioned information to the base station.

Figure 5 shows that on the basis of the quality measurement made by the subscriber terminal, preliminary candidates are selected for the transmission antenna, transmission direction or transmission beam of the base station. The final selection is made on the basis of the preliminary selection, and the final selection can be made either in the subscriber terminal or the base station depending on the case.

Figure 6 illustrates the selection process. Figure 6 shows areas 250 and 252 which are ellipse-shaped. The areas 250 and 252 overlap slightly. The overlapping area 251, which is common to the areas 250, 252, is marked with lines. When the area 251 common to the areas 250 and 252 is subtracted from the area 250, an area A remains. When the area common to the areas 250 and 252 is subtracted from the area 252, an area B remains. Let us assume that the antenna 140 transmits a signal S1 and the antenna 141 a signal S2. When the signals received by the subscriber terminal fulfil the quality condition (S_1<Th, S_2>Th) in the area A, the antenna 141 is selected. When the signals received by the subscriber terminal fulfil the condition (S_1>Th, S_2<Th) in the area B, the antenna 140 is selected. In the two previous cases, the subscriber terminal makes the final decision on the transmission antenna used by the base station.

If the signals received by the subscriber terminal are in the area 251, the subscriber terminal sends information to the base station that both

signals exceed the threshold. After receiving the information, the base station can, if necessary, select the antenna 140 and/or 141. In this situation, the base station makes the final selection on the transmission antenna. In addition to the antenna, it is also possible to select and make a decision on the transmission direction or the beam the base station uses for transmission. When the subscriber terminal transfers the decision selection to the base station, it simultaneously informs the base station of suitable antenna candidates. When the final decision on the selection is made in the base station, the means 102 in the base station selects the transmission beam causing the least interference. When the final decision on the selection is made in the subscriber terminal, the means 202 in the subscriber terminal selects the transmission beam causing the least interference to be the beam for the base station.

When the base station has been given the right to decide on the diversity antenna selection, the base station can make the decision on the transmission antenna on the basis of the load in the amplifier that feeds the antenna. The decision can, for instance, be based on the load of the network or amplifier at the moment on hand, or on a short-time or long-time load of the amplifier. The means 102 in the base station preferably selects the amplifier with the lowest load to feed the selected transmission antenna. This way, the load distribution of the amplifiers remains as even as possible all the time.

The actual load distribution of the amplifiers can be continuously estimated by various means. The means 102 can keep a record of the selections made during a longer period of time. In addition, the means 102 can keep a record of the current and short-term selections. The estimation can easily be done by means of two counters. The counter keeping track of the longer-term selections, can, for instance, calculate an average power for each amplifier. The counter keeping track of the short-term selections can instead monitor the maximum loads, for instance. The latter counter can, for instance, keep a record of the load situation of a time slot being transmitted at a given time. If several counters are used, the incidence probabilities of various load situations can be calculated by different statistical methods.

The load situation data can be utilized when updating the utilization rate data of the amplifiers. The data being updated can be weighted taking into consideration the data transmission rate used in transmission, because the data transmission rate is comparable with the required transmission power.

In practice this means that when transmitting a signal burst at a basic rate, the counter is incremented by one unit, for instance. When a burst is transmitted at q times the basic rate, the counter is incremented by one q unit.

Because the data transmission method is based on using a closed loop, the benefit derived from the use of the method is slightly reduced when the subscriber terminal moves at a high speed. When the radio system has detected that the rate of movement of the subscriber terminal exceeds a predefined limit rate, the base station can send to the subscriber terminal a command, on the basis of which the subscriber terminal stops transmitting the antenna selection bits to the base station. The radio system can utilize another diversity method for the downlink direction during the time that the subscriber terminal moves at a high speed. If the subscriber terminal can measure its own speed, the subscriber terminal can send information on a suitable transmission antenna to the base station. The selection of an antenna transmitting in the downlink direction can also be based on a combined selection in which the decision on the antenna is made on the basis of the decisions made by the subscriber terminal and the base station.

If there are M antennas, for instance, to select from, the amount of antenna selection information sent by the subscriber terminal depends on the capacity reserved for the transmission of said information at a given time. If the data field in the signal frame is large enough, information on the best antennas and their order of priority can be sent to the base station. It can be generalized that the more transmission antennas are used in the downlink direction, the more probable it is that the most optimal transmission antenna is selected. On the other hand, the subscriber terminal must then have enough capacity to transmit several selection bits to the base station.

A subscriber terminal acting as a receiver uses one or more threshold levels, the application of which enables the division and grouping of the signals in received channels. By means of the division, the downlink channels can be divided into different groups, such as 'good', 'average' and 'poor'.

The threshold or thresholds are set in such a manner that they divide the operating area as appropriately as possible so that the different channel spaces can be distinguished. When using only one threshold, special attention should be paid to selecting the threshold, because the channels are then divided relatively roughly. If the threshold is set too low, antenna selection

can be made on the basis of a channel having a high attenuation, which is not advisable. If the threshold is set too high, even good-quality channels may be rejected during the division process. Power control commands sent earlier can also be taken into account when setting the threshold.

If several channels are acceptable to the subscriber terminal for downlink transmission, the subscriber terminal lets the base station select the most suitable transmission antenna. The selection is based on the load of the power amplifiers in the base station. In the above situation, the base station can balance the load situation of the base stations within its own capability.

If signals, which when received are of 'poor' quality, are transmitted to the subscriber terminal on two different channels, the information on the quality of the channels can be sent to the base station in two bits by a signalling combination of '11', for instance. Using signalling, the subscriber terminal informs the base station that, in principle, none of the measured downlink channels are good for transmission, and consequently the transmission of said signals can be interrupted. Transmission interruption can be used when transmitting data in packets, for instance. When using real-time transmission and when all signals received by the subscriber terminal are below the threshold level, the antenna which transmitted the best signal is selected to continue transmitting the signal.

If the base station is sending data or non-real-time data, for instance, the base station can, if necessary, interrupt the transmission until better channel conditions are again available. This way, it is possible to avoid a situation in which the base station tries in vain to establish a connection by increasing its transmission power, thus increasing interference to other signals in the radio system. It is thus possible to prevent the occurrence of common channel interference, for instance, by means of the method. In real-time transmission, in which the signalling flow should be continuous, a base station can transmit a signal to the subscriber terminal through several antennas.

Even though the invention has been explained in the above with reference to an example in accordance with the accompanying drawings, it is obvious that the invention is not restricted to it but can be modified in many ways within the scope of the inventive idea disclosed in the attached claims.

CLAIMS

1. A data transmission method used in a radio system comprising a subscriber terminal (200) and at least one base station (100) which transmits signals to the subscriber terminal by means of its antenna (140, 141), **characterized** by

determining the quality of the signals received by the subscriber terminal by comparing the received signals with at least one signal quality threshold level,

sending to the base station (100), which transmitted the signal that exceeded the threshold, information on the antennas, which transmitted the signals that exceeded the threshold, or on the transmission directions from which the signal that exceeded the threshold was received,

selecting from the antennas, which transmitted the signal that exceeded the threshold, an antenna or antennas to continue the transmission of the signal to said subscriber terminal (200), or selecting from the transmission directions, from which the signal that exceeded the threshold was received, a transmission direction or directions, to which to continue the transmission of the signal to said subscriber terminal.

2. A data transmission method used in a radio system comprising a subscriber terminal (200) and at least one base station (100) which transmits signals to the subscriber terminal by means of its antenna (140, 141), **characterized** by

determining the quality of the signals received by the subscriber terminal (200) by comparing the received signals with at least one signal quality threshold level, and

when only one signal exceeds the threshold, sending to the base station (100), which transmitted the signal that exceeded the threshold, a command to use, when transmitting a signal to said subscriber terminal, the antenna with which the signal that exceeded the threshold was transmitted, or the transmission direction to which the signal that exceeded the threshold was transmitted.

3. A method as claimed in claim 1, **characterized** in that when the quality of several signals is within the acceptable levels, information on the quality of the signals is sent to the base station (100), and the base

station can, on the basis of the information, decide which antenna or direction it will use to continue transmitting the signal.

4. A method as claimed in claim 1, **characterized** in that the signals transmitted by the base stations are amplified by amplifiers (121), and in the method, the antenna which is connected to the amplifier with the lowest load is selected as the transmission antenna.

5. A method as claimed in claim 1, **characterized** in that the signals transmitted by the base stations are amplified by amplifiers (121) before transmission, and in the method, the selection decision is made on the basis of the load situation of the amplifiers.

6. A method as claimed in claim 1 or 2, **characterized** in that if the quality of the signal received by the subscriber terminal (200) is below the lowest acceptable quality level, information on the quality of the above-mentioned signal is sent to the base station which, after receiving the information, interrupts the transmission of the poor-quality signal.

7. A method as claimed in claim 1, **characterized** in that the signal is transmitted to the subscriber terminal (200) by means of beams, and the final decision on the transmission antenna, transmission direction or beam to be used by the base station is made in the base station (100).

8. A method as claimed in claim 2, **characterized** in that the signal is transmitted to the subscriber terminal (200) by means of beams, and the final decision on the transmission antenna, transmission direction or beam to be used by the base station is made in the subscriber terminal (200).

9. A method as claimed in claim 1, **characterized** in that the transmission beam of the base station causing the least interference is selected and the selection decision is made in the base station (100).

10. A method as claimed in claim 2, **characterized** in that the transmission beam of the base station causing the least interference is selected and the selection decision is made in the subscriber terminal (200).

11. A radio system comprising at least one subscriber terminal (200) and at least one base station (100) comprising an antenna (140, 141) by means of which the base station transmits signals to the subscriber terminal, **characterized** in that

the subscriber terminal comprises a measuring means (230) which determines the quality of the signals received by the subscriber terminal by comparing the received signals with at least one signal quality threshold level,

the subscriber terminal sends to the base station, which transmitted the signal that exceeded the threshold, information on the antennas by which the signal that exceeded the threshold was transmitted, or information on the transmission directions from which the signal that exceeded the threshold was received,

the base station (100) comprises a means (102) which selects from the antennas (140, 141), which transmitted the signals that exceeded the threshold, an antenna or antennas which continue to transmit the signal to said subscriber terminal (200), or the means (102) selects from the transmission directions of the signals, which exceeded the threshold, a transmission direction or directions to which the base station continues to transmit the signal.

12. A radio system comprising at least one subscriber terminal (200) and at least one base station (100) comprising an antenna (140, 141) by means of which the base station transmits signals to the subscriber terminal, **characterized** in that

the subscriber terminal (200) comprises a measuring means (230) which determines the quality of the signals received by the subscriber terminal by comparing the received signals with at least one signal quality threshold level, and

when only one signal exceeds the threshold, the subscriber terminal (200) sends to the base station (100), which transmitted the signal that exceeded the threshold, a command to use, when transmitting a signal to said subscriber terminal, the antenna with which the signal that exceeded the threshold was transmitted, or the transmission direction to which the signal that exceeded the threshold was transmitted.

13. A radio system as claimed in claim 11, **characterized** in that when the quality of several signals is within the acceptable levels, the subscriber terminal (200) sends to the base station information, on the basis of which the base station can decide which antenna (140, 141) or direction the base station will use to continue transmitting the signal.

14. A radio system as claimed in claim 11, **characterized** in that the base station comprises amplifiers (121) which amplify the signals before their transmission, and the means (102) selects as the transmission antenna of the base station the antenna or antennas which are connected to the amplifier with the smallest load.

15. A radio system as claimed in claim 11, **characterized** in that the base station comprises amplifiers (121) which amplify the signals before their transmission, and the means (102) makes the selection decision on the basis of the load situation of the amplifiers (121).

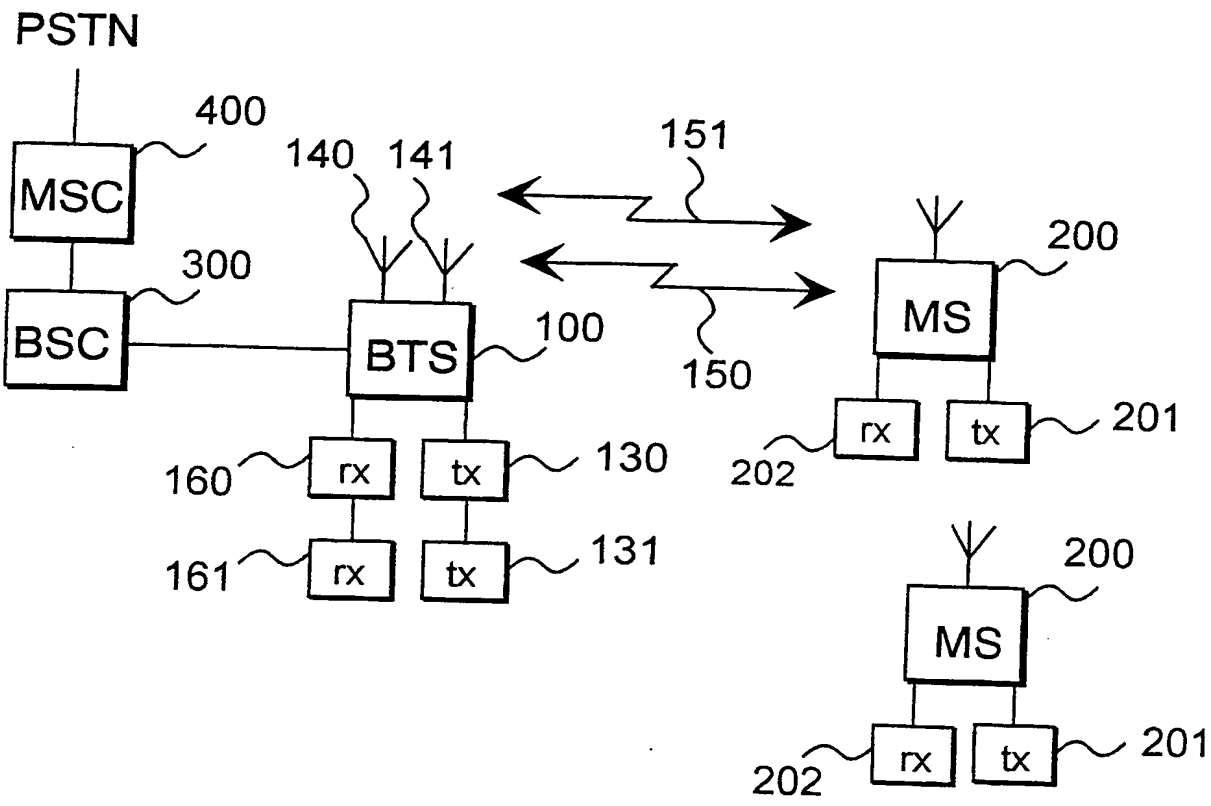
16. A radio system as claimed in claim 11 or 12, **characterized** in that if the quality of the signal received by the subscriber terminal is below the lowest acceptable quality level, the subscriber terminal (200) sends information on the quality of the above-mentioned signal to the base station which, after receiving the information, stops transmitting the signal with the antenna by which the signal that was below the threshold was transmitted.

17. A radio system as claimed in claim 11, **characterized** in that the base station (100) transmits the signal to the subscriber terminal (200) by means of beams, and the final decision on the transmission antenna, transmission direction or beam to be used in the base station is made in the base station (100).

18. A radio system as claimed in claim 12, **characterized** in that the base station (100) transmits the signal to the subscriber terminal (200) by means of beams, and the final decision on the transmission antenna, transmission direction or beam to be used in the base station (100) is made in the subscriber terminal (200).

19. A radio system as claimed in claim 11, **characterized** in that the base station comprises a means (102) which selects as the transmission beam of the base station the transmission beam causing the least interference.

20. A radio system as claimed in claim 12, **characterized** in that the subscriber terminal comprises a means (202) which selects as the transmission beam of the base station the transmission beam causing the least interference.


PSTN
400
MSC
140
141
151
300
BSC
BTS
100
150
200
MS
160
rx
tx
130
202
rx
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201
161
rx
tx
131
200
MS
202
rx
tx
201

Fig. 1

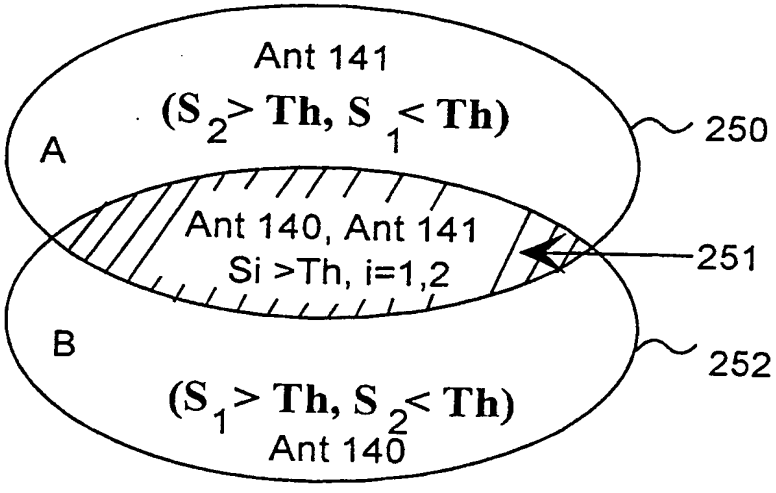
Ant 141
(S2> Th, S 1< Th)
A
250
Ant 140, Ant 141
Si >Th, i=1,2
251
B
252
(S1> Th, S 2< Th)
Ant 140

Fig. 5

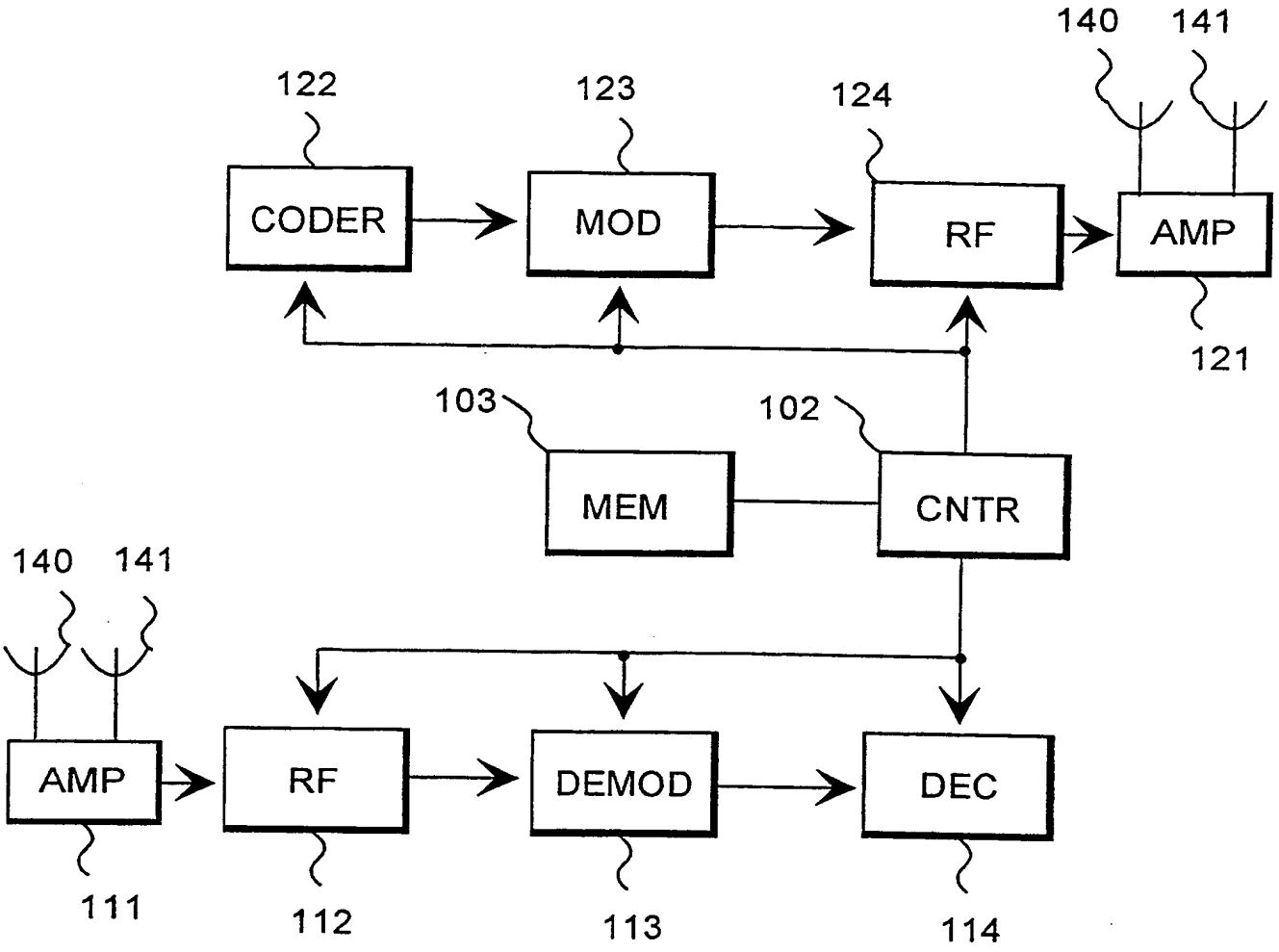
140
141
122
123
124
CODER
MOD
RF
AMP
121
103
102
MEM
CNTR
140
141
AMP
RF
DEMOD
DEC
111
112
113
114

Fig. 2

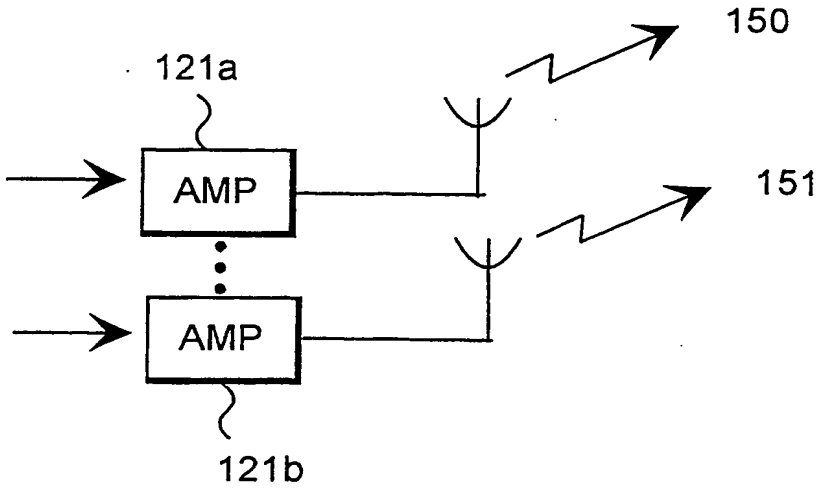
150
121a
AMP
151
AMP
121b

Fig. 3

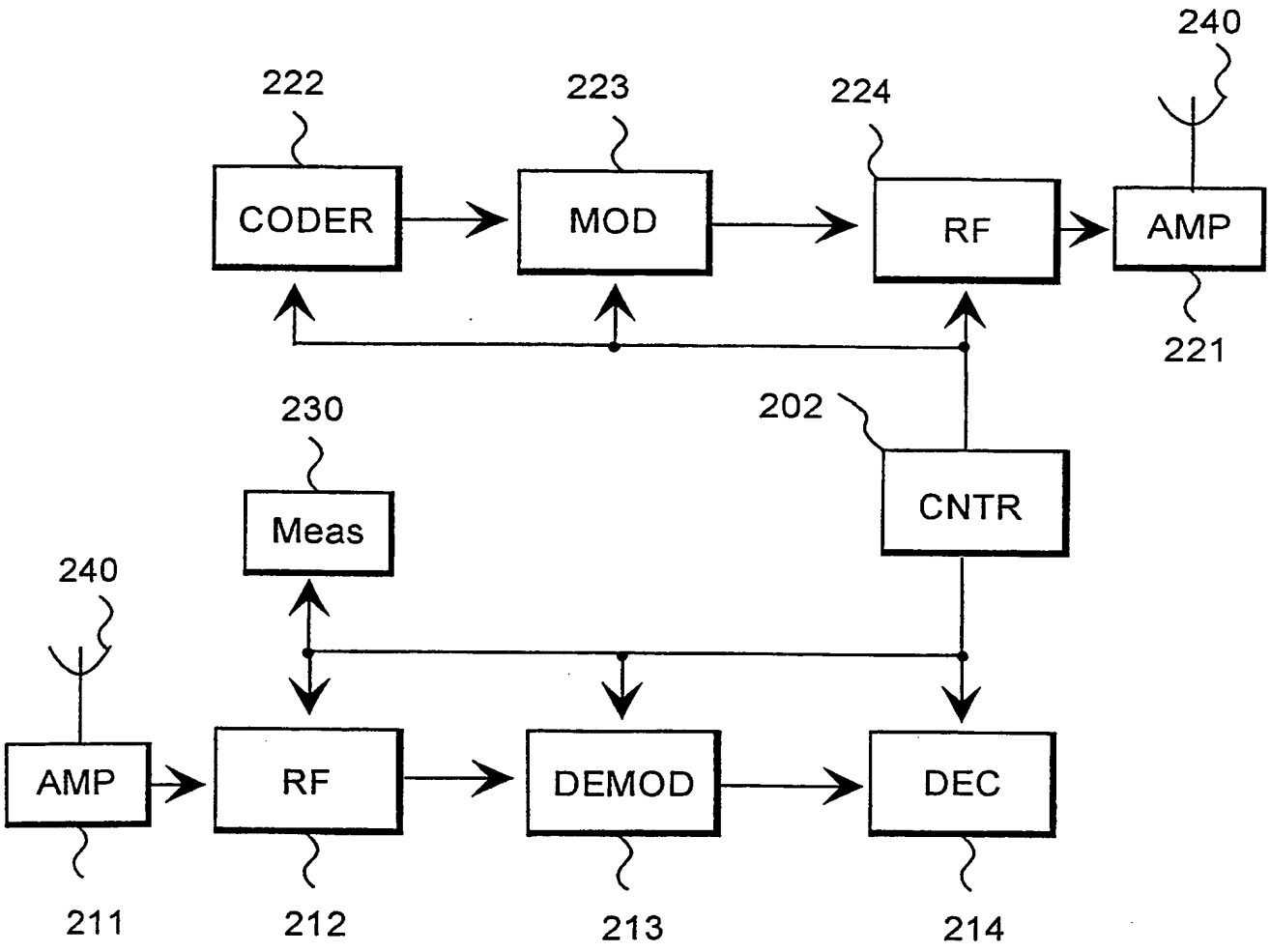
240
222
223
224
CODER
MOD
RF
AMP
221
230
202
Meas
CNTR
240
AMP
RF
DEMOD
DEC
211
212
213
214

Fig. 4

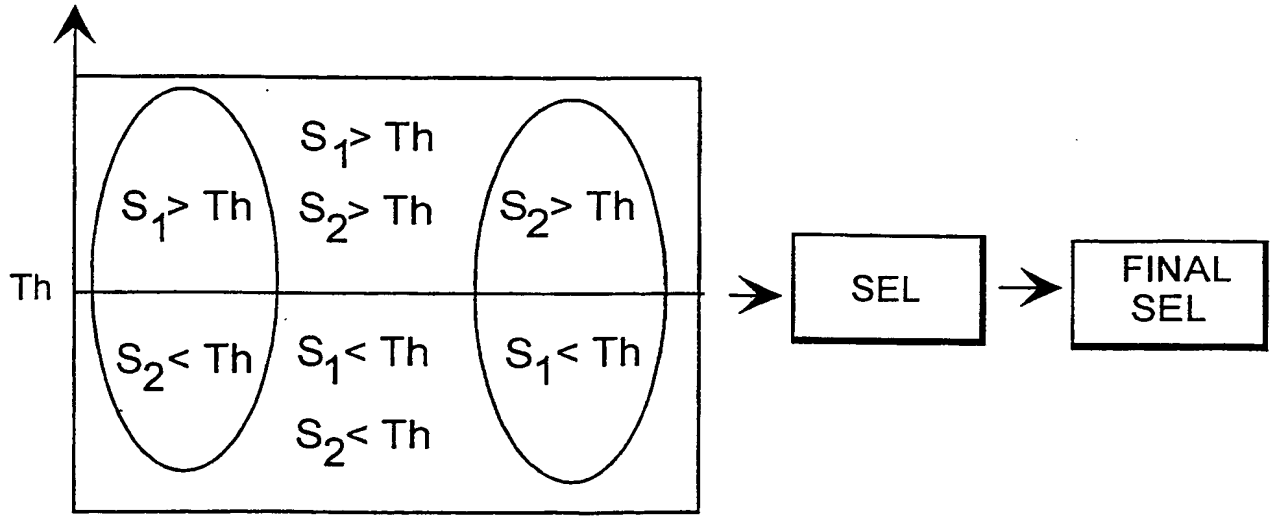
Th
S1> Th
S1> Th
S2> Th
S2> Th
S2< Th
S1< Th
S1< Th
S2< Th
SEL
FINAL SEL

Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 99/01062

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H04B 7/06
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5095535 A (T.A. FREEBURG), 10 March 1992 (10.03.92), column 8, line 43 - column 9, line 7, figures 4,5, claims	1,2,11,12
X	US 5455962 A (M.D. KOTZIN), 3 October 1995 (03.10.95), column 5, line 50 - column 6, line 10, claims	1,2,11,12
A	WO 9819401 A1 (NORTHERN TELECOM LIMITED), 7 May 1998 (07.05.98), abstract	1,2,11,12
A	EP 0696113 A2 (ASCOM BUSINESS SYSTEMS AG), 7 February 1996 (07.02.96), abstract	1,2,11,12

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 June 2000	19 JUN 2000
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Fredrik Blomqvist/AE Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 99/01062

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5530926 A (W.J. ROZANSKI), 25 June 1996 (25.06.96), figure 7, abstract -- --------	1,2,11,12

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/FI 99/01062

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5095535 A	10/03/92	AT 122512 T	15/05/95
		AU 615305 B	26/09/91
		AU 3607489 A	01/02/90
		CA 1327836 A	15/03/94
		CN 1023177 B	15/12/93
		CN 1039690 A	14/02/90
		DE 68922536 D,T	18/01/96
		DK 370389 A	29/01/90
		EP 0352787 A,B	31/01/90
		ES 2072876 T	01/08/95
		IL 90392 A	13/05/93
		JP 2079628 A	20/03/90
		JP 2838216 B	16/12/98
		KR 9707603 B	13/05/97
		MX 165383 B	06/11/92
US 5455962 A	03/10/95	NONE	
WO 9819401 A1	07/05/98	CA 2188845 A	25/04/98
		CA 2219096 A	25/04/98
		CA 2219228 A	25/04/98
		CN 1211359 A	17/03/99
		EP 0870371 A	14/10/98
		EP 0870372 A	14/10/98
		WO 9819402 A	07/05/98
EP 0696113 A2	07/02/96	NONE	
US 5530926 A	25/06/96	NONE	

PATENT COOPERATION TREATY

PCT

REC'D 26 JAN 2001
WIPO PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

15

Applicant's or agent's file reference T298100PC/nu	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/FI99/01062	International filing date *(day/month/year)* 21.12.1999	Priority date *(day/month/year)* 21.12.1998
International Patent Classification (IPC) or national classification and IPC7 H 04 B 7/06		
Applicant NOKIA NETWORKS OY et al		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets, including this cover sheet.

☒ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of 7 sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☐ Certain observations on the international application

CORRECTED VERSION

Date of submission of the demand	Date of completion of this report
17.07.2000	13.12.2000
Name and mailing address of the IPEA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. 08-667 72 88	Telex 17978 PATOREG-S
	Authorized officer Fredrik Blomqvist/mj Telephone No. 08-782 25 00

Form PCT/IPEA/409 (cover sheet) (January 1998)

CORRECTED

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/FI99/01062

I. Basis of the report

1. With regard to the **elements** of the international application:*

☐ the international application as originally filed

☒ the description:
pages 1-5 , as originally filed
pages _____ , filed with the demand
pages 6-12 , filed with the letter of 17.07.2000

☒ the claims:
pages 13-16 , as originally filed
pages _____ , as amended (together with any statement) under article 19
pages _____ , filed with the demand
pages _____ , filed with the letter of _____

☒ the drawings:
pages 1-3 , as originally filed
pages _____ , filed with the demand
pages _____ , filed with the letter of _____

☐ the sequence listing part of the description:
pages _____ , as originally filed
pages _____ , filed with the demand
pages _____ , filed with the letter of _____

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language English which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

☒ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☐ The amendments have resulted in the cancellation of:

☐ the description, pages _____

☐ the claims, Nos. _____

☐ the drawings, sheet/fig _____

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2 (c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

** *Any replacement sheet containing such amendments must be referred to under item I and annexed to this report.*

CORRECTED

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-20	YES
	Claims		NO
Inventive step (IS)	Claims	1-20	YES
	Claims		NO
Industrial applicability (IA)	Claims	1-20	YES
	Claims		NO

2. Citations and explanations (Rule 70.7)

The claimed invention is a diversity method and system to improve the quality of data transmission. The quality of the signals received by subscriber terminal from the base station antennas is measured and compared with set threshold level. When the quality of the signal exceeds the set level, the subscriber terminal sends quality information to base station. The antenna is selected using quality information and transmission direction.

The following documents were cited in the International Search Report:

D1) US 5455962 A
D2) US 5095535 A
D3) US 5530926 A
D4) WO 9819401 A1 (shows only state of the art)
D5) EP 0696113 A2 (shows only state of the art)

Document **D1** presents a cellular communication system using half-hopping and spatial diversity.

Document **D2** discloses a high bit rate communication system for overcoming multipath. It has a transmitter coupled to number of directional antenna for transmitting RF signal containing one terminal sector identifying information.

Document **D3** shows an operation of switched diversity receiver e.g. for TDMA or TDM systems
It selects one of two antennas by comparing quality of signals from both antennas.

.../...

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: Box V

The claimed invention differs from the cited documents in that neither of the documents comprise:
-determining the quality of the received signals by comparing the received signals with a quality threshold level
-sending to the base station information on the antenna that transmitted the signal that exceeded the threshold or sending to the base station information on the transmission directions from which the signal that exceeded the threshold was received
-selecting the antenna that transmitted the signal that exceeded the threshold to continue the transmission to the subscriber terminal or selecting the transmission direction that transmitted the signal that exceeded the threshold to continue the transmission of the signal to the subscriber terminal.

Therefore, the invention claimed in claims 1-20 is novel, comprise industrial applicability, and
is considered to involve an inventive step.

antennas can be at least 10 to 20fold, for instance, in relation to the used wavelength.

The antennas can also be adaptive antennas, for instance, in which case they allow the use of angle diversity in transmitting signals. The base station forms beams with the adaptive antennas to use in transmitting signals. The adaptive antennas are located at a distance of at most half of the used wavelength, for instance, in relation to each other.

The radio-frequency signal received by the base station is forwarded from the antenna to the amplifier 111 which amplifies the level of the received signal. The amplified signal is forwarded to the radio frequency part 112 which transfers the signal to an intermediate frequency. The radio frequency part 112 is connected to the demodulator 113 which returns the broadband signal to a narrowband data signal, if the signal in question is a CDMA signal. The invention is, however, not in any way restricted to the CDMA system, and the system can, for instance, be a TDMA system or a radio system operating according to another principle.

The data signal is forwarded from the demodulator 112 to the decoder 114 which decodes the data signal in a suitable manner. The signal coming in to the decoder 114 can be convolution-coded, for instance. The operation of the decoder 114 can be based on the Viterbi algorithm, for instance. Typically, the decoder 114 decrypts and deinterleaves the signal.

On the transmission side, the base station comprises an amplifier 121, a coder 122, a modulator 123 and a radio frequency part 124. The coder 122 receives a signal and, after coding it, transmits the signal to the modulator 123. The coder 122 can use convolution coding, for instance. In addition, the coder 122 encrypts the signal, for instance. The coder 122 also interleaves the signal bits or bit groups. In practice, the modulator 123 can act as a symbol modulator, for instance. If the transceiver is of CDMA type, the signal received from the modulator 123 is pseudo-random noise-coded into a broadband spread-spectrum signal. After this, the spread-spectrum signal is converted into radio frequency according to prior art in the radio frequency part 124. The radio-frequency signal is forwarded to the amplifier 121 which amplifies the signal. The amplified signal is transmitted via the antenna to the radio path. The base station also comprises a means 102 which controls the operation of the above-mentioned base station blocks, and a means 103 which stores data

on the load status of the amplifiers, for instance. The means 103 can be implemented with a memory circuit, for instance.

In practice, the receiving side of the base station comprises several receiver branches. Correspondingly, the transmitting side of the base station may comprise several transmitter branches and each transmitter branch can be connected to its own antenna, for instance. In addition, the signals going through each transmitter branch are typically forwarded to different amplifiers for amplification. Figure 3 illustrates the above-mentioned base station which has several amplifiers acting as power amplifiers on the transmitting side.

Figure 4 shows in greater detail the structure of the subscriber terminal used in the radio system of the invention. The subscriber terminal comprises an antenna 240, an amplifier 211, a radio frequency part 212, a demodulator 213, a decoder 214, an amplifier 221, a coder 222, a modulator 223 and a radio frequency part 224, an amplifier 221 and a control means 202. In principle, the above-mentioned subscriber terminal parts function in the same way as the parts corresponding to said parts in the base station. In addition, the subscriber terminal comprises a measuring means 230 which measures the quality of the signals received by the subscriber terminal. Measuring the quality can be based on measuring signal strength, amplitude-to-power ratio, S/N ratio, signal energy or signal bit error ratio, for instance. The measuring means can measure the signal quality continuously or periodically.

The subscriber terminal can simultaneously receive signals from either the same base station or from several base stations. The measuring means 230 in the subscriber terminal measures the received signals. The purpose for measuring the signal quality is to select the most optimal antenna for the radio system to transmit the signal to the subscriber terminal. The transmission direction or the beam used in transmission can also be selected on the basis of the signal quality measurement. The base station can use the load situation of an amplifier, for instance, as a selection criterion. Another purpose is that the final selection decision on the transmission antenna, transmission direction and/or amplifier is made either in the subscriber terminal or the base station.

The measuring means 230 compares the measured signal with one or more threshold levels. Figure 5 shows a diagram illustrating the purpose of use of the threshold levels used in the subscriber terminal. Let us assume that

the subscriber terminal receives a signal 150 transmitted by an antenna 140, and a signal 151 transmitted by an antenna 141. There is at least one threshold level for the received signals, with which the signal quality is compared. The threshold levels can be pre-set at fixed values, for instance. In measuring the received signal, the placement of the signal being measured is examined in relation to the threshold level. The signal being measured can be either below or above the threshold level. In some special cases, the signal being measured may be at exactly the threshold level. In the radio system of the invention, a method known as the B-STD diversity method (Balanced Selective Transmit Algorithm) is used to help select the transmission antenna and transmission direction of the base station. The signals of different antennas or beams can be distinguished from each other in the subscriber terminal on the basis of different codes, their pilot signal or training sequence code.

Let us assume that in Figure 5, the subscriber terminal receives a signal S1 and S2. Let us further assume that the base station antenna 140 transmits the signal S1 and the antenna 141 transmits the signal S2. When the quality of both signals exceeds the pre-set level Th, the subscriber terminal sends information on the quality of the signals to the base station, and consequently, either the antenna 140 which transmitted the signal S1 or the antenna 141 which transmitted the signal S2 can be selected as the final transmission antenna. In the above situation, both antennas 140, 141 can be selected as final transmission antennas. The same principle can also be used when selecting the beam or the transmission direction. In the situation described above, the base station makes the final decision on the transmission antenna, transmission beam or transmission direction on the basis of the information sent by the subscriber terminal. In practice, the means 102 in the base station makes the decision.

If the signal S1 exceeds the threshold, but the signal S2 is below it, the subscriber terminal sends information on the quality of the signals to the base station. After receiving the information, the base station continues to transmit the signal S1 through the antenna 140. If the signal S1 is below the threshold, but the signal S2 exceeds it, the subscriber terminal sends information on the quality of the signals to the base station, and having received it, the base station continues to transmit the signal S2 through

antenna 140. In the above-mentioned situations, the final decision on the transmission antenna, for instance, is already made in the subscriber terminal.

If both signals S1, S2 are below the threshold level, the subscriber terminal sends information on the quality of the signals to the base station which can, for instance, stop transmitting both signals. Therefore, the setting of the threshold level has a high significance. The threshold level can be set to a level, for instance, that when the signal received by the subscriber terminal is below it, the base station antenna which transmitted the signal will not be taken into consideration in the selection process. However, when the quality of the signal received by the subscriber terminal is above the threshold level, the base station antenna which transmitted the signal is considered in the selection process. In the case described above, the subscriber terminal can send the information on the signal quality or antenna selection in one bit. If the subscriber terminal receives signals with M antennas, M bits are required to send all above-mentioned information to the base station.

Figure 5 shows that on the basis of the quality measurement made by the subscriber terminal, preliminary candidates are selected for the transmission antenna, transmission direction or transmission beam of the base station. The final selection is made on the basis of the preliminary selection, and the final selection can be made either in the subscriber terminal or the base station depending on the case.

Figure 6 illustrates the selection process. Figure 6 shows areas 250 and 252 which are ellipse-shaped. The areas 250 and 252 overlap slightly. The overlapping area 251, which is common to the areas 250, 252, is marked with lines. When the area 251 common to the areas 250 and 252 is subtracted from the area 250, an area A remains. When the area common to the areas 250 and 252 is subtracted from the area 252, an area B remains. Let us assume that the antenna 140 transmits a signal S1 and the antenna 141 a signal S2. When the signals received by the subscriber terminal fulfil the quality condition (S_1<Th, S_2>Th) in the area A, the antenna 141 is selected. When the signals received by the subscriber terminal fulfil the condition (S_1>Th, S_2<Th) in the area B, the antenna 140 is selected. In the two previous cases, the subscriber terminal makes the final decision on the transmission antenna used by the base station.

If the signals received by the subscriber terminal are in the area 251, the subscriber terminal sends information to the base station that both

signals exceed the threshold. After receiving the information, the base station can, if necessary, select the antenna 140 and/or 141. In this situation, the base station makes the final selection on the transmission antenna. In addition to the antenna, it is also possible to select and make a decision on the transmission direction or the beam the base station uses for transmission. When the subscriber terminal transfers the decision selection to the base station, it simultaneously informs the base station of suitable antenna candidates. When the final decision on the selection is made in the base station, the means 102 in the base station selects the transmission beam causing the least interference. When the final decision on the selection is made in the subscriber terminal, the means 202 in the subscriber terminal selects the transmission beam causing the least interference to be the beam for the base station.

When the base station has been given the right to decide on the diversity antenna selection, the base station can make the decision on the transmission antenna on the basis of the load in the amplifier that feeds the antenna. The decision can, for instance, be based on the load of the network or amplifier at the moment on hand, or on a short-time or long-time load of the amplifier. The means 102 in the base station preferably selects the amplifier with the lowest load to feed the selected transmission antenna. This way, the load distribution of the amplifiers remains as even as possible all the time.

The actual load distribution of the amplifiers can be continuously estimated by various means. The means 102 can keep a record of the selections made during a longer period of time. In addition, the means 102 can keep a record of the current and short-term selections. The estimation can easily be done by means of two counters. The counter keeping track of the longer-term selections, can, for instance, calculate an average power for each amplifier. The counter keeping track of the short-term selections can instead monitor the maximum loads, for instance. The latter counter can, for instance, keep a record of the load situation of a time slot being transmitted at a given time. If several counters are used, the incidence probabilities of various load situations can be calculated by different statistical methods.

The load situation data can be utilized when updating the utilization rate data of the amplifiers. The data being updated can be weighted taking into consideration the data transmission rate used in transmission, because the data transmission rate is comparable with the required transmission power.

In practice this means that when transmitting a signal burst at a basic rate, the counter is incremented by one unit, for instance. When a burst is transmitted at q times the basic rate, the counter is incremented by one q unit.

Because the data transmission method is based on using a closed loop, the benefit derived from the use of the method is slightly reduced when the subscriber terminal moves at a high speed. When the radio system has detected that the rate of movement of the subscriber terminal exceeds a predefined limit rate, the base station can send to the subscriber terminal a command, on the basis of which the subscriber terminal stops transmitting the antenna selection bits to the base station. The radio system can utilize another diversity method for the downlink direction during the time that the subscriber terminal moves at a high speed. If the subscriber terminal can measure its own speed, the subscriber terminal can send information on a suitable transmission antenna to the base station. The selection of an antenna transmitting in the downlink direction can also be based on a combined selection in which the decision on the antenna is made on the basis of the decisions made by the subscriber terminal and the base station.

If there are M antennas, for instance, to select from, the amount of antenna selection information sent by the subscriber terminal depends on the capacity reserved for the transmission of said information at a given time. If the data field in the signal frame is large enough, information on the best antennas and their order of priority can be sent to the base station. It can be generalized that the more transmission antennas are used in the downlink direction, the more probable it is that the most optimal transmission antenna is selected. On the other hand, the subscriber terminal must then have enough capacity to transmit several selection bits to the base station.

A subscriber terminal acting as a receiver uses one or more threshold levels, the application of which enables the division and grouping of the signals in received channels. By means of the division, the downlink channels can be divided into different groups, such as 'good', 'average' and 'poor'.

The threshold or thresholds are set in such a manner that they divide the operating area as appropriately as possible so that the different channel spaces can be distinguished. When using only one threshold, special attention should be paid to selecting the threshold, because the channels are then divided relatively roughly. If the threshold is set too low, antenna selection

can be made on the basis of a channel having a high attenuation, which is not advisable. If the threshold is set too high, even good-quality channels may be rejected during the division process. Power control commands sent earlier can also be taken into account when setting the threshold.

If several channels are acceptable to the subscriber terminal for downlink transmission, the subscriber terminal lets the base station select the most suitable transmission antenna. The selection is based on the load of the power amplifiers in the base station. In the above situation, the base station can balance the load situation of the base stations within its own capability.

If signals, which when received are of 'poor' quality, are transmitted to the subscriber terminal on two different channels, the information on the quality of the channels can be sent to the base station in two bits by a signalling combination of '11', for instance. Using signalling, the subscriber terminal informs the base station that, in principle, none of the measured downlink channels are good for transmission, and consequently the transmission of said signals can be interrupted. Transmission interruption can be used when transmitting data in packets, for instance. When using real-time transmission and when all signals received by the subscriber terminal are below the threshold level, the antenna which transmitted the best signal is selected to continue transmitting the signal.

If the base station is sending data or non-real-time data, for instance, the base station can, if necessary, interrupt the transmission until better channel conditions are again available. This way, it is possible to avoid a situation in which the base station tries in vain to establish a connection by increasing its transmission power, thus increasing interference to other signals in the radio system. It is thus possible to prevent the occurrence of common channel interference, for instance, by means of the method. In real-time transmission, in which the signalling flow should be continuous, a base station can transmit a signal to the subscriber terminal through several antennas.

Even though the invention has been explained in the above with reference to an example in accordance with the accompanying drawings, it is obvious that the invention is not restricted to it but can be modified in many ways within the scope of the inventive idea disclosed in the attached claims.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 99/01062

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H04B 7/06
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5095535 A (T.A. FREEBURG), 10 March 1992 (10.03.92), column 8, line 43 - column 9, line 7, figures 4,5, claims --	1,2,11,12
X	US 5455962 A (M.D. KOTZIN), 3 October 1995 (03.10.95), column 5, line 50 - column 6, line 10, claims --	1,2,11,12
A	WO 9819401 A1 (NORTHERN TELECOM LIMITED), 7 May 1998 (07.05.98), abstract --	1,2,11,12
A	EP 0696113 A2 (ASCOM BUSINESS SYSTEMS AG), 7 February 1996 (07.02.96), abstract --	1,2,11,12

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 June 2000	19 JUN 2000
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Fredrik Blomqvist/AE Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 99/01062

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5530926 A (W.J. ROZANSKI), 25 June 1996 (25.06.96), figure 7, abstract -- --------	1,2,11,12

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/FI 99/01062

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5095535 A	10/03/92	AT 122512 T	15/05/95
		AU 615305 B	26/09/91
		AU 3607489 A	01/02/90
		CA 1327836 A	15/03/94
		CN 1023177 B	15/12/93
		CN 1039690 A	14/02/90
		DE 68922536 D,T	18/01/96
		DK 370389 A	29/01/90
		EP 0352787 A,B	31/01/90
		ES 2072876 T	01/08/95
		IL 90392 A	13/05/93
		JP 2079628 A	20/03/90
		JP 2838216 B	16/12/98
		KR 9707603 B	13/05/97
		MX 165383 B	06/11/92
US 5455962 A	03/10/95	NONE	
WO 9819401 A1	07/05/98	CA 2188845 A	25/04/98
		CA 2219096 A	25/04/98
		CA 2219228 A	25/04/98
		CN 1211359 A	17/03/99
		EP 0870371 A	14/10/98
		EP 0870372 A	14/10/98
		WO 9819402 A	07/05/98
EP 0696113 A2	07/02/96	NONE	
US 5530926 A	25/06/96	NONE	

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0 0-1	For receiving Office use only International Application No.	PCT/FI 9 9 / 0 1 0 6 2
0-2	International Filing Date	21 DEC 1999 (21. 12. 99)
0-3	Name of receiving Office and "PCT International Application"	The Finnish Patent Office PCT International Application
0-4 0-4-1	**Form - PCT/RO/101 PCT Request** Prepared using	PCT-EASY Version 2.90 (updated 15.10.1999)
0-5	**Petition** The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty	
0-6	**Receiving Office (specified by the applicant)**	National Board of Patents and Registration (Finland) (RO/FI)
0-7	**Applicant's or agent's file reference**	T298100PC/KO
I	**Title of invention**	DATA TRANSMISSION METHOD AND RADIO SYSTEM
II II-1 II-2 II-4 II-5 II-6 II-7	**Applicant** This person is: Applicant for Name Address: State of nationality State of residence	 applicant only all designated States except US NOKIA NETWORKS OY Keilalahdentie 4 FIN-02150 Espoo Finland FI FI
III-1 III-1-1 III-1-2 III-1-4 III-1-5 III-1-6 III-1-7	**Applicant and/or inventor** This person is: Applicant for Name (LAST, First) Address: State of nationality State of residence	 applicant and inventor US only KATZ, Marcos Aleksanterinkatu 15 A 7 FIN-90100 Oulu Finland AR FI

IV-1	**Agent or common representative; or address for correspondence** The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:	agent
IV-1-1	Name	PATENTTITOIMISTO TEKNOPOLIS KOLSTER OY
IV-1-2	Address:	c/o KOLSTER OY AB Iso Roobertinkatu 23 P.O.Box 148 FIN-00121 Helsinki Finland
IV-1-3	Telephone No.	358 9 618 821
IV-1-4	Facsimile No.	+358 9 602 244
V	**Designation of States**	
V-1	Regional Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	AP: GH GM KE LS MW SD SL SZ TZ UG ZW and any other State which is a Contracting State of the Harare Protocol and of the PCT EA: AM AZ BY KG KZ MD RU TJ TM and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT EP: AT BE CH&LI CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE and any other State which is a Contracting State of the European Patent Convention and of the PCT OA: BF BJ CF CG CI CM GA GN GW ML MR NE SN TD TG and any other State which is a member State of OAPI and a Contracting State of the PCT
V-2	National Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	AE AL AM AT (patent and utility model) AU AZ BA BB BG BR BY CA CH&LI CN CR CU CZ (patent and utility model) DE (patent and utility model) DK (patent and utility model) DM EE (patent and utility model) ES FI (patent and utility model) GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR (patent and utility model) KZ LC LK LR LS LT LU LV MA MD MG MK MN MW MX NO NZ PL PT RO RU SD SE SG SI SK (patent and utility model) SL TJ TM TR TT TZ UA UG US UZ VN YU ZA ZW

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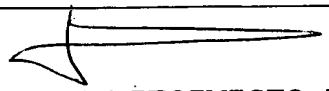
V-5	**Precautionary Designation Statement** In addition to the designations made under items V-1, V-2 and V-3, the applicant also makes under Rule 4.9(b) all designations which would be permitted under the PCT except any designation(s) of the State(s) indicated under item V-6 below. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit.		
V-6	**Exclusion(s) from precautionary designations**	NONE	
VI-1	**Priority claim of earlier national application**		
VI-1-1	Filing date	21 December 1998 (21.12.1998)	
VI-1-2	Number	982763	
VI-1-3	Country	FI	
VI-2	**Priority document request** The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) identified above as item(s):	VI-1	
VII-1	**International Searching Authority Chosen**	Swedish Patent Office (ISA/SE)	
VIII	**Check list**	number of sheets	electronic file(s) attached
VIII-1	Request	4	-
VIII-2	Description	12	-
VIII-3	Claims	4	-
VIII-4	Abstract	1	t298100p.txt
VIII-5	Drawings	3	-
VIII-7	TOTAL	24	
	Accompanying items	paper document(s) attached	electronic file(s) attached
VIII-8	Fee calculation sheet	✓	-
VIII-10	Copy of general power of attorney	✓	-
VIII-16	PCT-EASY diskette	-	diskette
VIII-17	Other (specified):	Copy of Official Action	-
VIII-18	**Figure of the drawings which should accompany the abstract**	1	
VIII-19	**Language of filing of the international application**	Finnish	
IX-1	**Signature of applicant or agent**	 Tapio Valkeiskangas	
IX-1-1	Name	PATENTTITOIMISTO TEKNOPOLIS KOLSTER OY	

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10-1	**Date of actual receipt of the purported international application**	21 DEC 1999	(21. 12. 99)

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10-2 10-2-1 10-2-2	**Drawings:** Received Not received	
10-3	**Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application**	
10-4	**Date of timely receipt of the required corrections under PCT Article 11(2)**	
10-5	**International Searching Authority**	ISA/SE
10-6	**Transmittal of search copy delayed until search fee is paid**	

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0-2	International Filing Date	2 1 DEC 1999 (2 1. 12. 99)
0-3	Name of receiving Office and "PCT International Application"	The Finnish Patent Office PCT International Application

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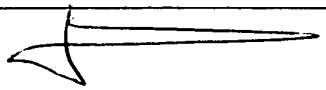
VIII-16	PCT-EASY diskette	-	diskette
VIII-17	Other (specified):	Copy of Official Action	-
VIII-18	**Figure of the drawings which should accompany the abstract**	1	
VIII-19	**Language of filing of the international application**	Finnish	
IX-1	**Signature of applicant or agent**	 Tapio Valkeiskangas	
IX-1-1	Name	PATENTTITOIMISTO TEKNOPOLIS KOLSTER OY	

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10-1	**Date of actual receipt of the purported international application**	21 DEC 1999	(21. 12. 99)

PCT REQUEST T298100PC/KO

Original (for **SUBMISSION**) - printed on 21.12.1999 01:44:06 PM

10-2 10-2-1 10-2-2	**Drawings:** Received Not received	
10-3	**Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application**	
10-4	**Date of timely receipt of the required corrections under PCT Article 11(2)**	
10-5	**International Searching Authority**	**ISA/SE**
10-6	**Transmittal of search copy delayed until search fee is paid**	

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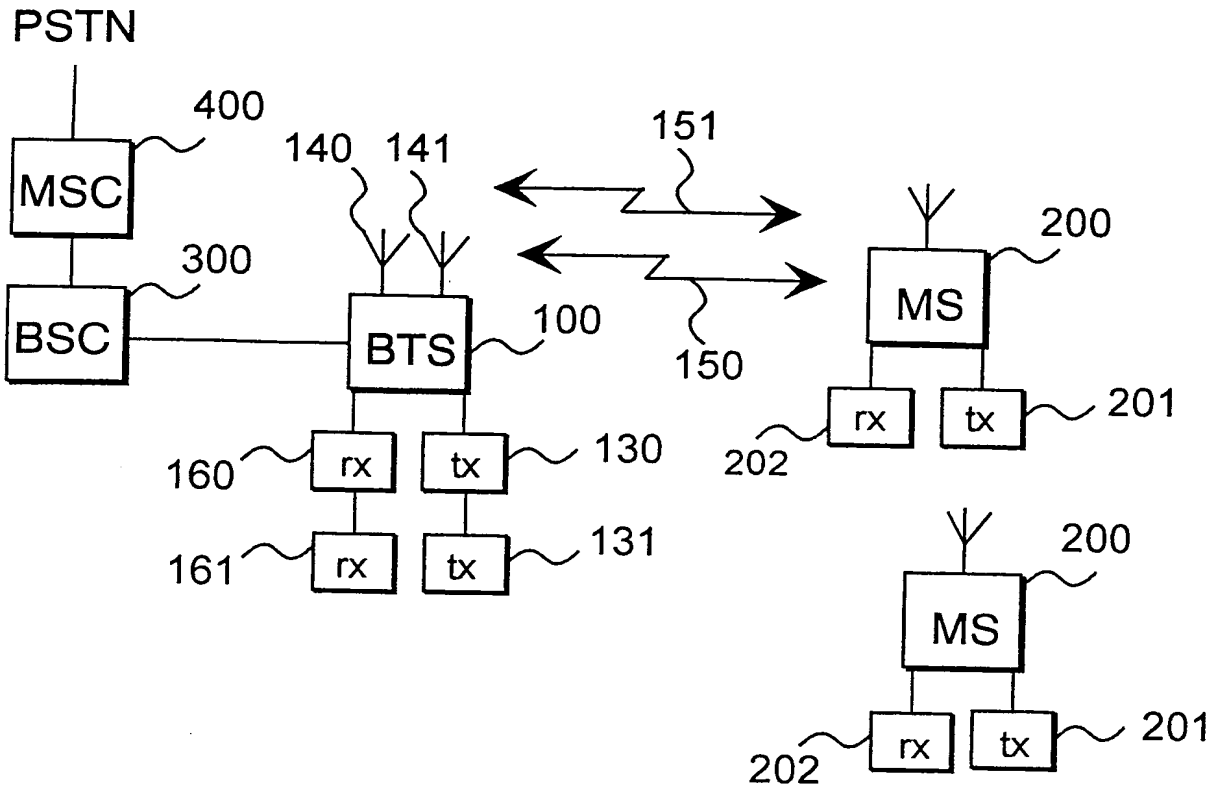
11-1	**Date of receipt of the record copy by the International Bureau**	02 FEBRUARY 2000	(02.02.00)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rx
tx
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Fig. 1

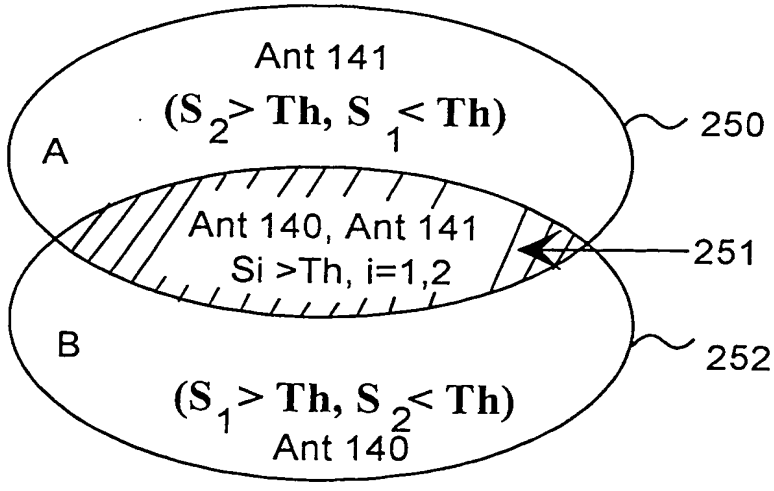
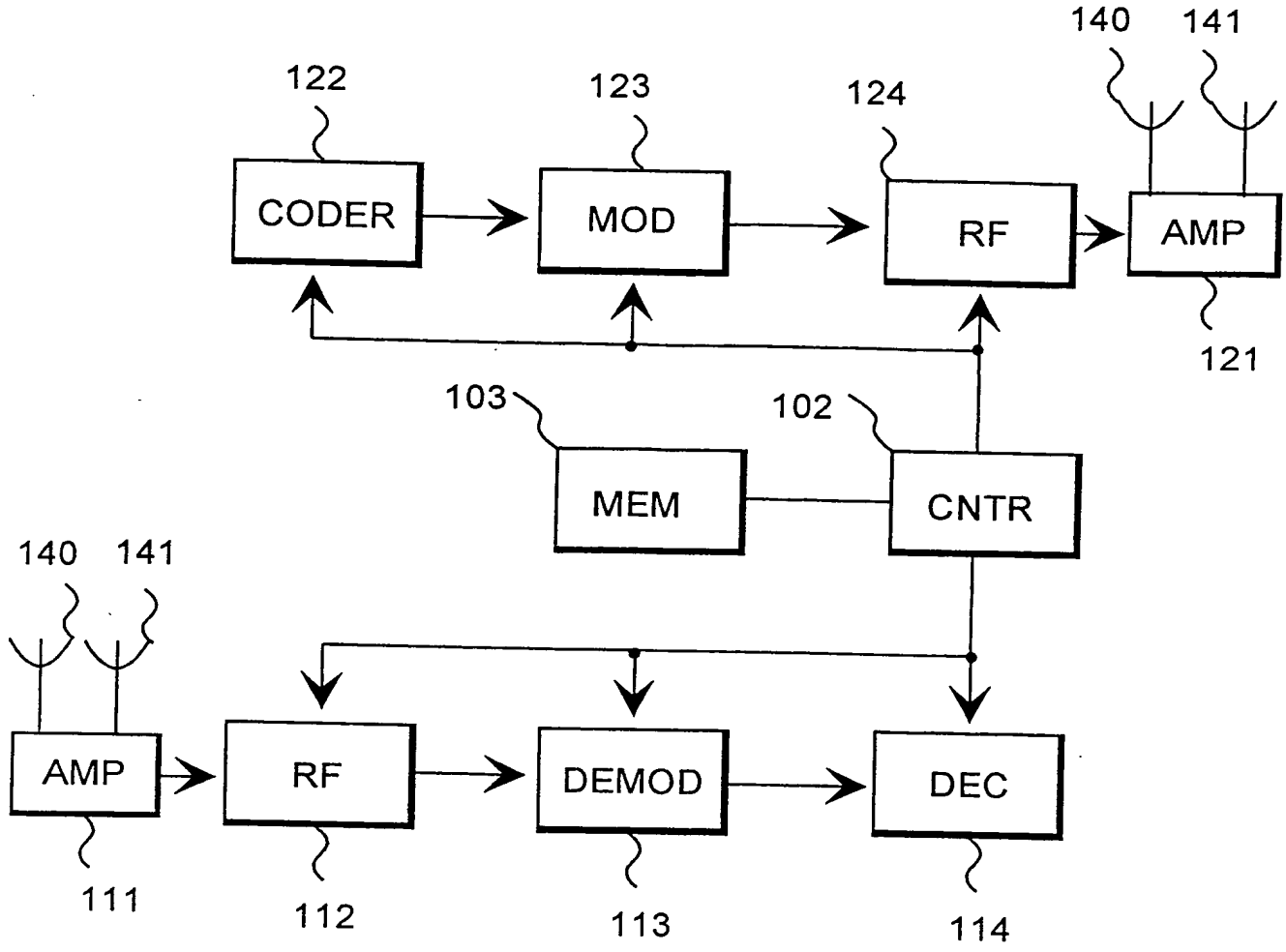

Ant 141
(S2> Th, S 1< Th)
A
250
Ant 140, Ant 141
Si >Th, i=1,2
251
B
252
(S1> Th, S 2< Th)
Ant 140

Fig. 5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112
113
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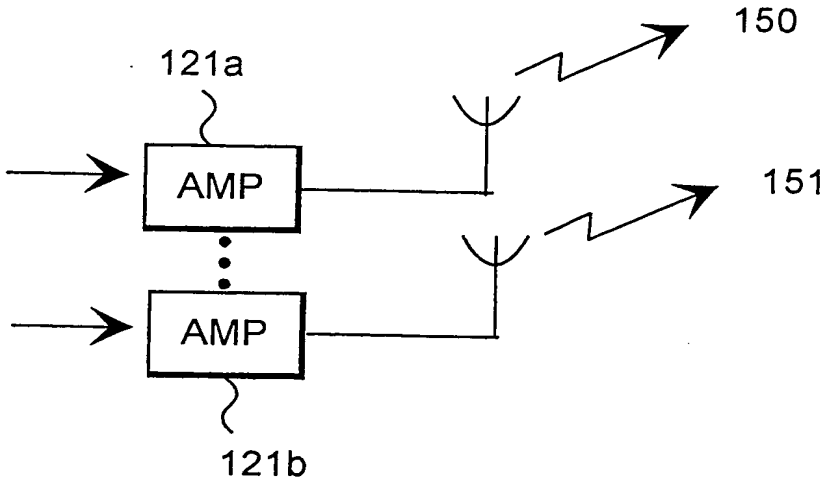
Fig. 2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121a
AMP
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121b

Fig. 3

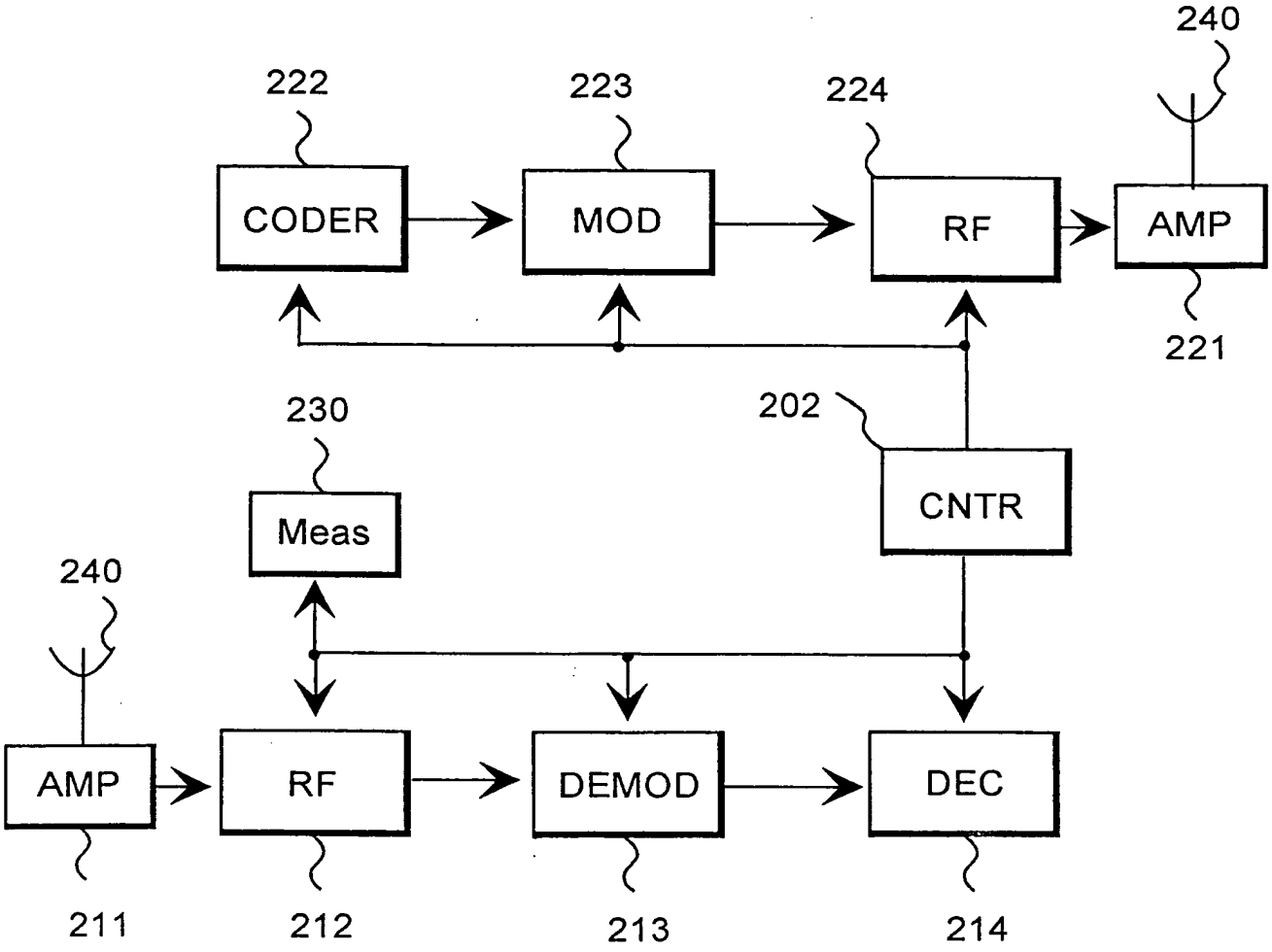
240
222
223
224
CODER
MOD
RF
AMP
221
230
202
Meas
CNTR
240
AMP
RF
DEMOD
DEC
211
212
213
214

Fig. 4

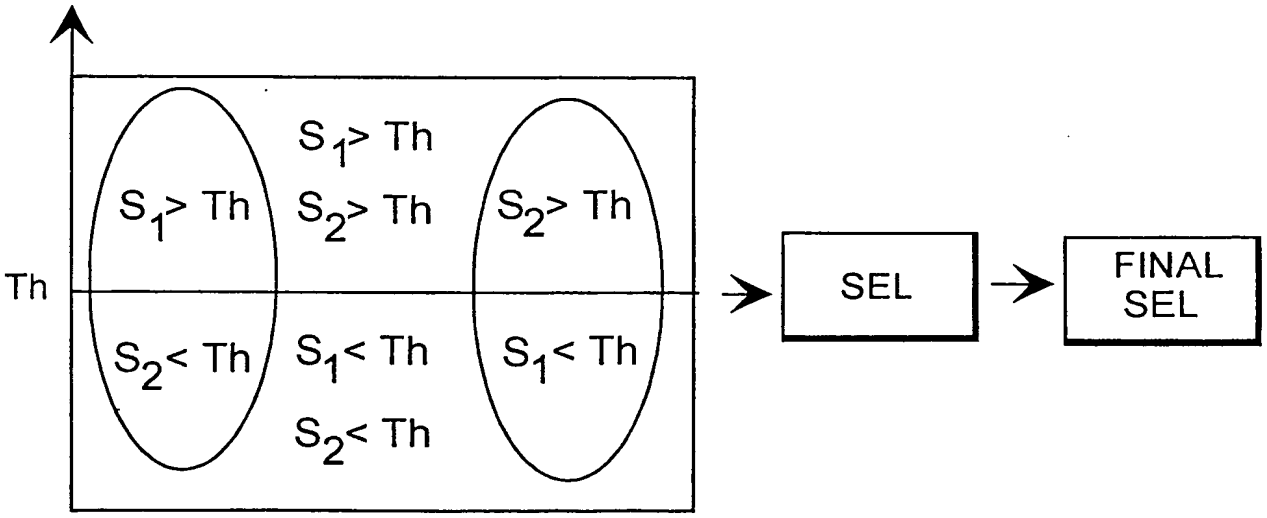
Th
S1> Th
S2> Th
S1> Th
S2> Th
S2< Th
S1< Th
S2< Th
S1< Th
SEL
FINAL SEL

Fig. 6

Tiedonsiirtomenetelmä ja radiojärjestelmä

Keksinnön ala

Keksinnön kohteena on tiedonsiirtomenetelmä, jota käytetään radiojärjestelmässä, joka koostuu tilaajapäätelaitteesta ja ainakin yhdestä tukiasemasta, joka lähettää antenninsa avulla tilaajapäätelaitteelle signaaleja.

Keksinnön tausta

Tunnetun tekniikan mukaisissa radiojärjestelmissä käytetään signaalien lähetyksessä erilaisia diversiteettimenetelmiä, joiden avulla tiedonsiirron laatua parannetaan. Erilaisista diversiteettimenetelmistä voidaan mainita esimerkiksi ortogonaalinen lähetysdiversiteetti (OTD = Orthogonal Transmit Diversity), aikakytkentäinen lähetysdiversiteetti (TSTD = Time Switching Transmit Diversity) ja valintainen lähetysdiversiteetti (STD = Selective Transmit Diversity). Edellä mainittuja diversiteettimenetelmiä on mahdollista käyttää esimerkiksi tulevaisuuden WCDMA-järjestelmissä. Mainituilla menetelmillä voidaan parantaa esimerkiksi BER-suorituskykyä tiedonsiirrossa. Edellä mainituista menetelmistä etenkin STD-menetelmällä saavutetaan suurimmat edut verrattuna esimerkiksi OTD- ja TSTD-menetelmiin.

FDD-järjestelmissä STD-menetelmää voidaan käyttää esimerkiksi antennien valinnassa. Tuolloin radiojärjestelmässä tilaajapäätelaite, joka voi olla esimerkiksi matkapuhelin, valitsee ja informoi tukiasemaa valitsemaan mahdollisimman optimaalisen antennin, jota tukiaseman kannattaa käyttää downlink-suuntaisessa signaalin lähetyksessä. Antennien valinta perustuu tukiasema-antennien lähettämien signaalien laadun mittaamiseen ja saatujen mittaustulosten keskinäiseen vertaamiseen.

Kuitenkin STD-menetelmien käyttäminen aiheuttaa kuormitusongelmia lähetinvastaanottimen tehovahvistimissa. Ongelmat johtuvat siitä, että tehovahvistimien kuormitus ei läheskään aina jakaannu eri tehovahvistimien kesken tasaisesti, vaan kuormituserot voivat olla hyvinkin suuria. Esimerkiksi CDMA-tyyppisessä radiojärjestelmässä voi käytännössä olla tilanne, jossa tukiaseman jokin tietty lähetyshaara valitaan lähettämään signaaleja suurelle joukolle tilaajapäätelaitteita, jotka muodostavat signaalien avulla samanaikaisia yhteyksiä. Tällainen valintamenetelmä edellyttää lähetyshaarassa olevalta tehovahvistimelta hyvin suurta dynamiikkaa. Laaja dynamiikka edellyttää, että tehovahvistimien suunnittelussa käytetään suurta crest-kerrointa, joka määri-

tellään vahvistimelta vaadittavan maksimitehon ja keskimääräisen tehon suhteesta.

Oletetaan, että tukiasema käsittää ensimmäisen ja toisen lähetysantennin, jotka lähettävät signaalia samalle tilaajapäätelaitteelle. Oletetaan vielä, että tukiasema käsittää ensimmäisen tehovahvistimen, joka syöttää signaaliaan ensimmäiselle lähetysantennille, ja toisen tehovahvistimen, joka syöttää signaaliaan toiselle lähetysantennille. Mikäli tilaajapäätelaite sijaitsee edullisessa paikassa suhteessa esimerkiksi ensimmäiseen lähetysantenniin, vastaanottaa tilaajapäätelaite laadultaan ainakin jonkin verran parempaa signaalia ensimmäiseltä lähetysantennilta. Käytännössä voi olla hyvinkin mahdollista, että toisenkin antennin lähettämä signaali vastaanotetaan laadultaan suhteellisen hyvänä. Mikäli antenni valitaan lähettämään signaalia matkapuhelimille, joita esimerkiksi K-kappaletta ja joista jokaiselle tukiaseman tehovahvistin lähettää signaalia teholla P, pitää tukiaseman tehovahvistimen dynamiikka ainakin yltää tehotasolle KP.

Koska antennien valinta perustuu pelkästään signaalin absoluuttisen laadun mittaamiseen, lähettää tilaajapääte tukiasemalla käskyn käyttää ensimmäistä lähetysantennia. Mikäli tarpeeksi moni tilaajapäätelaite komentaa tukiasemaa käyttämään ensimmäistä lähetysantennia, voi ensimmäisen tehovahvistimen nimellinen kuormitettavuus ylittyä. Mikäli tilaajapäätelaite on joutunut valitsemaan esimerkiksi kahdesta tukiasema-antennista paremman, on tilaajapäätelaite voinut lähettää tiedon valinnasta käyttämällä yhtä valintabittiä. Valintabitin arvo on voinut olla edellämainitussa tilanteessa esimerkiksi '1', joka on tarkoittanut esimerkiksi ensimmäisen lähetysantennin valintaa. Valintabitin arvo '0' on merkinnyt tukiaseman toisen lähetysantennin valintaa.

Valintamenetelmä ei ole kuitenkaan ollut optimaalinen tehovahvistimien kuormituksen kannalta, koska käytetty menetelmä on voinut johtaa valittua lähetysantennia syöttävän tehovahvistimen ylikuormittumiseen. Tehovahvistimien kuormitus on siis joissakin tilanteissa ollut liian paljon epätasapainossa. Mainitut ongelmat ovat ainakin osaksi johtuneet siitä, että signaalin laadun mittaaminen on perustunut absoluuttisiin arvoihin, mikä ei ole johtanut koko järjestelmän toiminnan kannalta parhaaseen mahdolliseen lopputulokseen.

Keksinnön lyhyt selostus

Keksinnön tavoitteena on siten toteuttaa menetelmä ja menetelmän toteuttava laitteisto siten, että yllä mainitut ongelmat saadaan ratkaistua. Tämä

saavutetaan johdannossa esitetyn tyyppisellä tiedonsiirtomenetelmällä, jolle on tunnusomaista, että määritetään tilaajapäätelaitteen vastaanottamien signaalien laadukkuus vertaamalla vastaanotettuja signaaleja ainakin yhteen signaalin laadun kynnystasoon, lähetetään kynnyksen ylittäneen signaalin lähettäneelle tukiasemalle tieto antenneista, jotka lähettivät kynnyksen ylittäneitä signaaleja, tai tieto lähetyssuunnista, joista kynnyksen ylittänyttä signaalia vastaanotettiin, valitaan antenneista, jotka lähettivät kynnyksen ylittänyttä signaalia, antenni tai antennit, jotka jatkavat signaalin lähettämistä mainitulle tilaajapäätelaitteelle, tai valitaan lähetyssuunnista, joista vastaanotettiin kynnyksen ylittänyttä signaalia, lähetyssuunta tai lähetyssuunnat, joihin signaalin lähettämistä mainitulle tilaajapäätelaitteelle jatketaan.

Lisäksi tämä saavutetaan johdannossa esitetyn tyyppisellä tiedonsiirtomenetelmällä, jolle on tunnusomaista, että määritetään tilaajapäätelaitteen vastaanottamien signaalien laadukkuus vertaamalla vastaanotettuja signaaleja ainakin yhteen signaalin laadun kynnystasoon, ainoastaan yhden signaalin ylittäessä kynnyksen, lähetetään kynnyksen ylittäneen signaalin lähettäneelle tukiasemalla komento käyttää signaalin lähettämisessä mainitulle tilaajapäätelaitteelle antennia, jolla lähetettiin kynnyksen ylittänyt signaali, tai lähetyssuuntaa, johon kynnyksen ylittänyt signaali lähetettiin.

Keksinnön kohteena on myös radiojärjestelmä, joka käsittää ainakin yhden tilaajapäätelaitteen ja ainakin yhden tukiaseman, joka käsittää antennin, jonka avulla tukiasema lähettää signaaleja tilaajapäätelaitteelle.

Keksinnön mukaiselle radiojärjestelmälle on tunnusomaista, että tilaajapäätelaite käsittää mittausvälineen, joka määrittää tilaajapäätelaitteen vastaanottamien signaalien laadukkuuden vertaamalla vastaanotettuja signaaleja ainakin yhteen signaalin laadun kynnystasoon, tilaajapäätelaite lähettää kynnyksen ylittäneen signaalin lähettäneelle tukiasemalle tiedon antenneista, joiden avulla kynnyksen ylittänyt signaali lähetettiin, tai tiedon lähetyssuunnista, joista kynnyksen ylittänyt signaali vastaanotettiin, tukiasema käsittää välineen, joka valitsee kynnyksen ylittäneiden signaaleiden lähettäneistä antenneista antennin tai antennit, jotka jatkavat signaalin lähettämistä mainitulle tilaajapäätelaitteelle, tai väline valitsee kynnyksen ylittäneiden signaalin lähetyssuunnista lähetyssuunnan tai lähetyssuunnat, joihin tukiasema jatkaa signaalin lähettämistä.

Lisäksi keksinnön mukaiselle radiojärjestelmälle on tunnusomaista, että tilaajapäätelaite käsittää mittausvälineen, joka määrittää tilaajapäätelait-

teen vastaanottamien signaalien laadukkuuden vertaamalla vastaanotettuja signaaleja ainakin yhteen signaalin laadun kynnystasoon, ainoastaan yhden signaalin ylittäessä kynnyksen, tilaajapäätelaite lähettää kynnyksen ylittäneen signaalin lähettäneelle tukiasemalle komennon käyttää signaalin lähettämisessä mainitulle tilaajapäätelaitteelle sitä antennia, jonka avulla tukiasema lähetti kynnyksen ylittäneen signaalin, tai sitä lähetyssuuntaa, johon kynnyksen ylittänyt signaali lähetettiin.

Keksinnön edulliset suoritusmuodot ovat epäitsenäisten patenttivaatimusten kohteena.

Keksintö perustuu siihen, että tilaajapääte mittaa tukiaseman lähettämiä signaaleja vertaamalla signaaleja kynnystasoon, ja tukiaseman käyttämä lähetysantenni, lähetyssuunta tai keila valitaan tilanteen mukaan joko tilaajapäätelaitteessa tai tukiasemassa.

Keksinnön mukaisella tiedonsiirtomenetelmällä ja radiojärjestelmällä saavutetaan useita etuja. Keksinnön mukaisen menetelmän avulla saadaan radiojärjestelmän tukiasemassa olevien vahvistimien kuormitus jaettua joka hetki mahdollisimman tasaisesti jokaisen vahvistimen kesken. Koska kuormitus pysyy tasaisena, vahvistimien dynamiikan ei tarvitse olla niin suuri kuin tunnetun tekniikan mukaisissa radiojärjestelmissä käytettävissä vahvistimissa, jolloin vahvistimien suunnittelu helpottuu.

Menetelmällä minimoidaan tehovahvistimien välillä kulloinkin oleva kuormitusepätasapaino antamalla tarvittaessa tukiaseman valita downlink-suuntaisen lähetyksen lähetysantenni. Mikäli tukiasemassa käytetään adaptiivisia antenneja, voidaan keksinnön mukaisella menetelmällä valita sellainen lähetyssuunta, joka aiheuttaa mahdollisimman vähän interferenssiä muille radioverkon signaaleille.

Lisäksi menetelmä mahdollistaa joustavasti toimivan radiojärjestelmän toteuttamisen. Keksinnön mukaisen radiojärjestelmän vastaanottimessa, joka on tilaajapäätelaite, jaotellaan vastaanotetut signaalit kynnystasojen avulla eri signaaliryhmiin kuuluviksi. Useampien kynnysten käyttäminen mahdollistaa kanavien joustavamman allokoinnin vastaanottimille. Lisäksi kynnysten käyttäminen parantaa antennivalinnan luotettavuutta. Keksinnön mukainen ratkaisu on suhteellisen helppo toteuttaa esimerkiksi signalointia muuttamalla.

Kuvioiden lyhyt selostus

Keksintöä selostetaan nyt lähemmin edullisten suoritusmuotojen yhteydessä, viitaten oheisiin piirroksiin, joissa

kuvio 1 esittää keksinnön mukaista radiojärjestelmää,
kuvio 2 esittää radiojärjestelmän tukiaseman rakennetta,
kuvio 3 esittää tarkemmin tukiasemaa,
kuvio 4 esittää radiojärjestelmässä olevan tilaajapäätelaitteen rakennetta,
kuvio 5 selventää kynnystasojen käyttötarkoitusta,
kuvio 6 selventää radiojärjestelmässä käytettävää valintaprosessia.

Keksinnön yksityiskohtainen selostus

Kuvio 1 esittää radiojärjestelmän, joka käsittää tukiaseman 100, tilaajapäätelaitteita 200, tukiasemaohjaimen 300 ja matkapuhelinkeskuksen 400. Tilaajapäätelaitteet 200 voivat olla esimerkiksi matkapuhelimia. Tukiasema käsittää lähettimiä 130, 131 ja vastaanottimia 160, 161. Lisäksi tukiasema käsittää antenneja 140, 141, joiden avulla tukiasema lähettää ja vastaanottaa signaalia. Tukiasema lähettää tilaajapäätelaitteelle ja vastaanottaa tilaajapäätelaitteelta antenninsa 140 avulla signaalia 150. Lisäksi tukiasema lähettää tilaajapäätelaitteelle ja vastaanottaa tilaajapäätelaitteelta antenninsa 141 avulla signaalia 151. Kuviosta nähdään, että tilaajapäätelaite käsittää lähettimen 201 ja vastaanottimen 202. Tilaajapäätelaite voi vastaanottaa signaaleja, jotka on lähetetty tukiaseman eri antenneilta. Tilaajapäätelaitteen vastaanottamat signaalit, jotka sisältävät saman informaation, voivat olla myös eri tukiasemien lähettämiä.

Kuvio 2 esittää tarkemmin keksinnön mukaisessa radiojärjestelmässä olevan tukiaseman 100 rakennetta. Tukiasema käsittää antennit 140, 141, jotka toimivat käytännössä lähetinvastaanotinantenneina. Lisäksi tukiasema käsittää vastaanottopuolella vahvistimen 111, radiotaajuusosan 112, demodulaattorin 113 ja dekooderin 114. Tukiasema voi käyttää lähetyksessä esimerkiksi antennidiversiteettiä. Käytettäessä antennidiversiteettiä, sijoitetaan antennit tarpeeksi kauas toisistaan. Antennien etäisyys voi olla vähintään esimerkiksi 10 - 20 -kertainen käytettyyn aallonpituuteen nähden.

Antennit voivat olla myös esimerkiksi adaptiivisia antenneja, jolloin ne mahdollistavat kulmadiversiteetin käyttämisen signaalien lähetyksessä. Tukiasema muodostaa adaptiivisten antennien avulla keiloja, joiden avulla tukiasema lähettää signaaleja. Adaptiiviset antennit sijoitetaan toisiinsa nähden etäisyydelle, joka on esimerkiksi enintään puolet käytetystä aallonpituudesta.

Tukiaseman vastaanottama radiotaajuinen signaali viedään antennista vahvistimelle 111, joka vahvistaa vastaanottamansa signaalin tasoa.

Vahvistettu signaali viedään radiotaajuusosalle 112, joka siirtää signaalin välitaajuudelle. Radiotaajuusosa 112 ovat yhteydessä demodulaattoriin 113, joka palauttaa laajakaistaisen signaalin kapeakaistaiseksi datasignaaliksi, mikäli kyseessä on CDMA-signaali. Keksintö ei kuitenkaan rajoitu mitenkään CDMA-järjestelmään, vaan järjestelmä voi olla esimerkiksi TDMA-järjestelmä tai jollakin muulla periaatteella toimiva radiojärjestelmä.

Datasignaali viedään demodulaattorilta 112 dekooderille 114, joka dekoodaa datasignaalin sopivalla tavalla. Dekooderille 114 tuleva signaali voi olla esimerkiksi konvoluutiokoodattu. Dekooderin 114 toiminta voi perustua esimerkiksi Viterbi-algoritmiin. Tyypillisesti dekooderi 114 purkaa signaalin salauksen ja lomituksen.

Tukiasema käsittää lähetyspuolella vahvistimen 121, kooderin 122, modulaattorin 123 ja radiotaajuusosan 124. Kooderin 122 vastaanottaa signaalia ja lähettää koodaamansa signaalin modulaattorille 123. Kooderi 122 voi käyttää koodauksessa esimerkiksi konvoluutiokoodausta. Lisäksi kooderi 122 suorittaa signaalille esimerkiksi salauksen. Edelleen kooderi 122 lomittaa signaalin bitit tai bittiryhmät. Modulaattori 123 voi toimia käytännössä esimerkiksi symbolimodulaattorina. Kun lähetinvastaanotin on CDMA-tyyppinen, modulaattorilta 123 saatu signaali valekohinakoodataan laajakaistaiseksi hajaspektrisignaaliksi. Tämän jälkeen hajaspektrisignaali muunnetaan radiotaajuiseksi tunnetun tekniikan mukaisesti radiotaajuusosassa 124. Radiotaajuinen signaali viedään vahvistimelle 121, joka vahvistaa signaalin. Vahvistettu signaali lähetetään antennin kautta radiotielle. Edelleen tukiasema käsittää välineen 102, joka ohjaa edellä mainittujen tukiasemalohkojen toimintaa, ja välineen 103, johon talletetaan tietoja esimerkiksi vahvistimien kuormitustilanteista. Väline 103 voidaan toteuttaa esimerkiksi muistipiirillä.

Käytännössä tukiaseman vastaanottopuoli koostuu useista vastaanotinhaaroista. Vastaavasti tukiaseman lähetyspuoli voi koostua useista lähetinhaaroista, jolloin jokainen lähetinhaara voidaan kytkeä esimerkiksi omaan antenniinsa. Lisäksi jokaisen lähetinhaaran kautta menevät signaalit viedään vahvistettavaksi tyypillisesti eri vahvistimille. Kuvio 3 selventää edellä mainittua tukiasemaa, joka käsittää lähetyspuolella useita vahvistimia, jotka toimivat tehovahvistimina.

Kuvio 4 esittää tarkemmin keksinnön mukaisessa radiojärjestelmässä käytettävän tilaajapäätelaitteen rakennetta. Tilaajapäätelaite käsittää antennin 240, vahvistimen 211, radiotaajuusosan 212, demodulaattorin 213, dekooderin

214, vahvistimen 221, kooderin 222, modulaattorin 223 ja radiotaajuusosan 224, vahvistimen 221 ja ohjausvälineen 202. Edellä mainitut tilaajapäätelaitteen osat periaatteessa toimivat samalla tavalla kuin mainittuja osia vastaavat osat tukiasemassa. Lisäksi tilaajapäätelaite käsittää mittausvälineen 230, joka mittaa tilaajapäätelaitteen vastaanottamien signaalien laadukkuutta. Laadukkuuden mittaaminen voi perustua esimerkiksi signaalin voimakkuuden, amplitudi-teho-suhteen, S/N-suhteen, signaalin energian tai signaalin bittivirhesuhteen mittaamiseen. Mittausväline voi mitata signaalin laadukkuutta jatkuvalla tavalla tai ajoittain.

Tilaajapäätelaite voi samanaikaisesti vastaanottaa signaaleja joko samalta tai usealta eri tukiasemalta. Tilaajapäätelaitteessa oleva mittausväline 230 mittaa vastaanotettuja signaaleja. Signaalien laadun mittaamisen tarkoituksena on valita radiojärjestelmän kannalta mahdollisimman optimaalinen antenni lähettämään tilaajapäätelaitteelle signaalia. Signaalin laadun mittaamisen perusteella voidaan valita myös lähetyssuunta tai lähetyksessä käytettävä keila. Tukiasema voi käyttää eräänä valintakriteerinä esimerkiksi vahvistimen kuormitustilannetta. Edelleen tarkoituksena on se, että tukiaseman lähetysantennin, lähetyssuunnan ja/tai vahvistimen lopullinen valintapäätös tehdään joko tilaajapäätelaitteessa tai tukiasemassa.

Mittausväline 230 vertaa mittaamaansa signaalia yhteen tai useampaan kynnystasoon. Kuviossa 5 esitetään kaavio, joka selventää tilaajapäätelaitteessa käytettävien kynnystasojen käyttötarkoitusta. Oletetaan, että tilaajapäätelaite vastaanottaa signaalia 150, jonka on lähettänyt antenni 140, ja signaalia 151, jonka on lähettänyt antenni 141. Vastaanotettuja signaaleja varten on ainakin yksi kynnystaso, johon signaalin laatua verrataan. Kynnystasot voivat olla esimerkiksi ennalta asetettu kiinteisiin arvoihin. Vastaanotetun signaalin mittaamisessa tarkastellaan mitattavan signaalin sijoittumista suhteessa kynnystasoon. Mitattava signaali voi olla joko jonkin kynnystason ala- tai yläpuolella. Joissakin erikoistapauksissa mitattava signaali voi olla juuri kynnystason suuruinen. Keksinnön mukaisessa radiojärjestelmässä käytetään ns. B-STD-diversiteettimenetelmää (B-STD = Balanced Selective Transmit Algorithm) apuna tukiaseman lähetysantennin ja lähetyssuunnan valitsemisessa. Eri antennien tai eri keilojen signaalit voidaan erottaa tilaajapäätelaitteessa toisistaan eri koodien, pilottisignaalin tai esimerkiksi opetusjakson perusteella.

Oletetaan kuvioon 5 liittyen, että tilaajapäätelaite vastaanottaa signaalia S1 ja S2. Oletetaan vielä, että tukiaseman antenni 140 lähettää signaa-

lia S1 ja että antenni 141 lähettää signaalia S2. Kun kummankin signaalin laatu ylittää ennalta asetetun tason Th, lähettää tilaajapäätelaite tiedon signaalien laadusta tukiasemalle, jolloin voidaan joko signaalin S1 lähettänyt antenni 140 tai signaalin S2 lähettänyt antenni 141 valita lopulliseksi lähetysantenniksi. Edellä mainitussa tilanteessa voidaan lopullisiksi lähetysantenneiksi myös valita molemmat antennit 140, 141. Samalla periaatetta voidaan käyttää myös keilan tai lähetyssuunnan valitsemisessa. Edellä selostetussa tilanteessa tukiasema tekee tilaajapäätelaitteen lähettäminen tietojen perusteella lopullisen päätöksen lähetysantennista, lähetyskeilasta tai lähetyksen suunnasta. Käytännössä tukiasemassa päätöksen tekee väline 102.

Mikäli signaali S1 ylittää kynnyksen, mutta signaali S2 on kynnystason alapuolella, lähettää tilaajapäätelaite tiedon signaalien laadusta tukiasemalle. Tiedon saatuaan tukiasema jatkaa signaalin S1 lähettämistä antennilla 140. Mikäli taas signaali S1 on kynnyksen alapuolella, mutta signaali S2 ylittää kynnystason, lähettää tilaajapäätelaite signaalien laadusta tukiasemalle tiedon, jonka saatuaan tukiasema jatkaa signaalin S2 lähettämistä antennilla 140. Edellä mainituissa tilanteissa lopullinen päätös esimerkiksi lähetysantennista tehdään siis jo tilaajapäätelaitteessa.

Mikäli molemmat signaalit S1, S2 ovat kynnystason alapuolella, lähettää tilaajapäätelaite tiedon signaalien laadusta tukiasemalle, joka voi esimerkiksi keskeyttää kummankin signaalin lähettämisen. Kynnystason asettamiskohdalla on siis hyvin suuri merkitys. Kynnystaso voidaan asettaa esimerkiksi sellaiseksi, että tilaajapäätelaitteen vastaanottaman signaalin ollessa kynnystason alapuolella, ei signaalin lähettänyttä tukiasema-antennia oteta huomioon valintaprosessissa. Sen sijaan tilaajapäätelaitteen vastaanottaman signaalin laadun ollessa kynnystason yläpuolella, otetaan signaalin lähettänyt tukiasema-antenni huomioon valintaprosessissa. Edellä kuvatussa tapauksessa voi tilaajapäätelaite lähettää tiedon signaalin laadusta tai antennivalinnasta yhdellä bitillä. Mikäli tilaajapäätelaite vastaanottaa signaaleja antenneilta, joita on M-kappaletta, tarvitaan M-kappaletta bittejä, jotta kaikki edellä mainitut tiedot voidaan lähettää tukiasemalle.

Kuviosta 5 nähdään, että tilaajapäätelaitteen suorittaman laatumittauksen perusteella valitaan alustavat ehdokkaat tukiaseman lähetysantenniksi, lähetyssuunnaksi tai lähetyskeilaksi. Alustavien valintojen perusteella tehdään lopullinen valinta, joka voidaan tehdä tapauksesta riippuen joko tilaajapäätelaitteessa tai tukiasemassa.

Kuvio 6 selventää valintaprosessia. Kuviossa 6 esitetään alueet 250 ja 252, jotka ovat ellipsin muotoisia. Alueet 250 ja 252 limittyvät jonkin verran. Limittyvä alue 251, joka on yhteinen alueille 250, 252, on kenoviivoitettu. Kun alueesta 250 vähennetään alueiden 250 ja 252 yhteinen alue 251, jää erotukseksi alue A. Kun alueesta 252 vähennetään alueiden 250 ja 252 yhteinen alue, jää erotukseksi alue B. Oletetaan edelleen, että antenni 140 lähettää signaalia S1 ja että antenni 141 lähettää signaalia S2. Kun tilaajapäätelaitteen vastaanottamat signaalit täyttävät alueella A olevan laatuehdon (S_1<Th, S_2>Th), valitaan antenni 141. Kun taas tilaajapäätelaitteen vastaanottamat signaalit täyttävät alueella B olevan ehdon (S_1>Th, S_2<Th), valitaan antenni 140. Kahdessa edellisessa tapauksessa tilaajapäätelaite tekee lopullisen päätöksen tukiaseman käyttämästä lähetysantennista.

Mikäli taas tilaajapäätelaitteen vastaanottamat signaalit ovat alueella 251, tilaajapäätelaite lähettää tukiasemalle tiedon, että molemmat signaalit ylittävät kynnyksen. Tiedon saatuaan tukiasema voi halutessaan valita antennin 140 ja/tai antennin 141. Tässä tilanteessa tukiasema tekee lopullisen lähetysantennivalinnan. Antennin lisäksi voidaan valita ja tehdä päätös esimerkiksi lähetyssuunnasta tai keilasta, jota tukiasema käyttää lähetyksessään. Kun tilaajapäätelaite siirtää päätösvalinnan tukiasemalle, niin samalla tilaajapäätelaite informoi tukiasemaa sopivista antenniehdokkaista. Kun lopullinen valintapäätös tehdään tukiasemassa, valitsee tukiasemassa oleva väline 102 lähetyskeilaksi vähiten interferenssiä aiheuttavan lähetyskeilan. Kun taas lopullinen valintapäätös tehdään tilaajapäätelaitteessa, valitsee tilaajapäätelaitteessa oleva väline 202 tukiaseman lähetyskeilaksi vähiten interferenssiä aiheuttavan lähetyskeilan.

Kun tukiasemalle on annettu oikeus päättää diversiteettiantennivalinnasta, voi tukiasema tehdä valintapäätöksen lähetysantennista vahvistimen, joka syöttää antennia, kuormituksen perusteella. Päätös voi perustua esimerkiksi verkon tai vahvistimen senhetkiseen kuormitukseen, vahvistimen lyhyen tai pitemmän ajan kuormitukseen. Tukiasemassa oleva väline 102 valitsee syöttämään valittua lähetysantennia edullisesti sen vahvistimen, jolla on pienin kuormitus. Tällä tavalla vahvistimien kuormitustilanne pysyy koko ajan mahdollisimman hyvin tasapainossa.

Vahvistimien todellista kuormitustilannetta voidaan jatkuvasti estimoida erilaisilla tavoilla. Väline 102 voi pitää lukua pitemmän ajan aikana tehdyistä valinnoista. Lisäksi väline 102 voi pitää lukua senhetkistä ja lyhyen ajan

valinnoista. Estimoinnit voidaan toteuttaa helposti esimerkiksi kahden laskurin avulla. Pitemmän ajan aikana tehtyjä valintoja lukuapitävä laskuri voi laskea esimerkiksi keskitehon jokaiselle vahvistimelle. Sen sijaan lyhyen ajan aikana tehtyjä valintoja lukuapitävä laskuri voi pitää lukua esimerkiksi maksimikuormitustilanteista. Viimeksimainittu laskuri voi pitää lukua esimerkiksi juuri sillä hetkellä lähetettävän aikavälin aikaisesta kuormitustilanteesta. Mikäli käytetään useampia laskureita, voidaan eri kuormitustilanteiden esiintymistodennäköisyyksiä laskea erilaisilla tilastollisilla menetelmillä.

Kuormitustilannetietoja voidaan käyttää hyväksi vahvistimien käyttöastetietojen päivittämisessä. Päivitettäviä tietoja voidaan painottaa ottamalla huomioon lähetyksessä käytetty tiedonsiirtonopeus, koska tiedonsiirtonopeus on verrannollinen vaadittuun lähetystehoon. Tämä tarkoittaa käytännössä sitä, että lähetettäessä signaalipurske perusnopeudella, kasvatetaan laskuria esimerkiksi yhdellä yksiköllä. Kun taas purske lähetetään esimerkiksi q-kertaisella perusnopeudella, kasvatetaan laskuria q-yksikön verran.

Koska tiedonsiirtomenetelmä perustuu ns. suljetun silmukan käyttämiseen, pienenee menetelmän käytöstä saatava hyöty jonkin verran, kun tilaajapäätelaite liikkuu suurella nopeudella. Kun radiojärjestelmä on havainnut tilaajapäätelaitteen liikenopeuden ylittävän ennalta määrätyn rajanopeuden, voi tukiasema lähettää tilaajapäätelaitteelle komennon, jonka perusteella tilaajapäätelaite keskeyttää antennivalintabittien lähettämisen tukiasemalle. Radiojärjestelmässä voidaan ottaa käyttöön jokin toinen downlink-suunnassa käytettävä diversiteettimenetelmä siksi ajaksi kun tilaajapäätelaite liikkuu suurella nopeudella. Mikäli tilaajapäätelaite kykenee itse mittaamaan nopeutensa, voi tilaajapäätelaite lähettää tukiasemalle tiedon sopivasta lähetysantennista. Downlink-suuntaan lähettävän antennin valinta voi perustua myös ns. yhdistettyyn valintaan, jossa päätös antennista tehdään tilaajapäätelaitteen tekemän päätöksen ja tukiaseman tekemän päätöksen perusteella.

Mikäli valittavia antenneja on esimerkiksi M-kappaletta, on tilaajapäätelaitteen lähettämän antennivalintainformaation määrä riippuvainen em. informaation lähetykseen kulloinkin varatusta kapasiteetista. Mikäli signaalikehyksessä oleva datakenttä on tarpeeksi suuri, voidaan informaatio parhaista antenneista ja tieto niiden paremmuusjärjestyksestä lähettää tukiasemalle. Yleistyksenä voidaan todeta, että mitä useampia lähetysantenneja downlink-suunnan lähetyksessä käytetään, sitä todennäköisemmin saadaan optimaalisin lähetysantenni valituksi. Toisaalta tuolloin tilaajapäätelaitteella pitää olla

kapasiteettia lähettää useampia valintabittejä tukiasemalle.

Tilaajapäätelaitteessa, joka toimii vastaanottimena, käytetään siis yhtä tai useampaa kynnystasoa, jonka soveltaminen mahdollistaa vastaanotetuissa kanavissa olevien signaalien jaottelun ja ryhmittelyn. Jaottelun avulla voidaan downlink-suuntaiset kanavat erotella eri ryhmiin kuten esimerkiksi 'hyvä', 'keskinkertainen' ja 'huono'.

Kynnys tai kynnykset asetetaan siten, että ne jakavat toiminta-alueen mahdollisimman tarkoituksenmukaisesti, jolloin eri kanavatilat voidaan erottaa. Kun käytetään vain yhtä kynnystä, pitää erityistä huomiota käyttää kynnyksen valinnassa, koska kanavien erotteleminen tehdään tuolloin suhteellisen karkeasti. Jos kynnys asetetaan liian alas, niin antennivalinta voidaan tehdä suuren vaimennuksen omaavan kanavan perusteella, mikä ei ole suotavaa. Jos kynnys on asetettu liian korkealla, niin hyvälaatuisia kanaviakin voidaan hylätä kanavien jaotteluprosessin aikana. Kynnyksen asettamisessa voidaan ottaa huomioon myös aiemmin lähetetyt tehonsäätökomennot.

Mikäli useampi kanava on tilaajapäätelaitteen kannalta hyväksyttävissä downlink-suuntaiseen lähetykseen, antaa tilaajapäätelaite tukiasemalle päätösvallan valinta sopivimman lähetysantennin. Valinta perustuu tukiasemassa olevien tehovahvistimien kuormitustilanteeseen. Edellä mainitussa tilanteessa tukiasema voi tasapainottaa mahdollisuuksiensa mukaan tukiasemien kuormitustilannetta.

Mikäli taas tilaajapäätelaitteelle lähetetään kahdella eri kanavalla signaaleja, jotka ovat vastaanotettaessa laadultaan 'huonoja', voidaan tiedot kanavien laadusta ilmoittaa tukiasemalle kahdella bitillä, esimerkiksi signaloin-tikombinaatiolla '11'. Signaloinnin avulla tilaajapäätelaite informoi tukiasemaa, että periaatteessa mikään mitatuista downlink-suunnan kanavista ei ole hyvä käytettäväksi lähetykseen, jolloin mainittujen signaalien lähettäminen voidaan keskeyttää. Lähetyksen keskeytystä voidaan käyttää lähetettäessä dataa esimerkiksi paketeissa. Kun käytetään reaaliaikaista lähetystä ja kun tilaajapäätelaitteen vastaanottamista signaaleista kaikki alittavat laatukynnyksen, valitaan parhaimman signaalin lähettänyt antenni jatkamaan signaalin lähetystä.

Mikäli tukiasema on lähettämässä dataa tai esimerkiksi ei-reaaliaikaista tietoa, voi tukiasema tarvittaessa keskeyttää lähetyksen kunnes paremmat kanavaolosuhteet ovat jälleen saatavilla. Näin voidaan välttää tilanne, jossa tukiasema yrittää turhaan luoda yhteyden nostamalla lähetystehonsa, jolloin häiriöt radiojärjestelmän muille signaaleille lisääntyvät. Menetelmällä on

siis mahdollista ehkäistä esimerkiksi yhteiskanavahäiriöiden syntyminen. Reaaliaikaisessa lähetyksessä, jossa signalointivirran pitäisi olla jatkuvaa, voi tukiasema lähettää tilaajapäätelaitteella signaalia useammankin antennin avulla.

Vaikka keksintöä on edellä selostettu viitaten oheisten piirustusten mukaiseen esimerkkiin, on selvää, ettei keksintö ole rajoittunut siihen, vaan sitä voidaan muunnella monin tavoin oheisten patenttivaatimusten esittämän keksinnöllisen ajatuksen puitteissa.

Patenttivaatimukset

1. Tiedonsiirtomenetelmä, jota käytetään radiojärjestelmässä, joka koostuu tilaajapäätelaitteesta (200) ja ainakin yhdestä tukiasemasta (100), joka lähettää antenninsa (140, 141) avulla tilaajapäätelaitteelle signaaleja, t u n n e t t u siitä, että

määritetään tilaajapäätelaitteen vastaanottamien signaalien laadukkuus vertaamalla vastaanotettuja signaaleja ainakin yhteen signaalin laadun kynnystasoon,

lähetetään kynnyksen ylittäneen signaalin lähettäneelle tukiasemalle (100) tieto antenneista, jotka lähettivät kynnyksen ylittäneitä signaaleja, tai tieto lähetyssuunnista, joista kynnyksen ylittänyttä signaalia vastaanotettiin,

valitaan antenneista, jotka lähettivät kynnyksen ylittänyttä signaalia, antenni tai antennit, jotka jatkavat signaalin lähettämistä mainitulle tilaajapäätelaitteelle (200), tai valitaan lähetyssuunnista, joista vastaanotettiin kynnyksen ylittänyttä signaalia, lähetyssuunta tai lähetyssuunnat, joihin signaalin lähettämistä mainitulle tilaajapäätelaitteelle jatketaan.

2. Tiedonsiirtomenetelmä, jota käytetään radiojärjestelmässä, joka koostuu tilaajapäätelaitteesta (200) ja ainakin yhdestä tukiasemasta (100), joka lähettää antenninsa (140, 141) avulla tilaajapäätelaitteelle signaaleja, t u n n e t t u siitä, että

määritetään tilaajapäätelaitteen (200) vastaanottamien signaalien laadukkuus vertaamalla vastaanotettuja signaaleja ainakin yhteen signaalin laadun kynnystasoon,

ainoastaan yhden signaalin ylittäessä kynnyksen, lähetetään kynnyksen ylittäneen signaalin lähettäneelle tukiasemalla (100) komento käyttää signaalin lähettämisessä mainitulle tilaajapäätelaitteelle antennia, jolla lähetettiin kynnyksen ylittänyt signaali, tai lähetyssuuntaa, johon kynnyksen ylittänyt signaali lähetettiin.

3. Patenttivaatimuksen 1 mukainen menetelmä, t u n n e t t u siitä, että useamman signaalin laadun ollessa hyväksyttävissä olevien tasojen välissä, lähetetään signaalien laadusta tukiasemalle (100) tieto, joka perusteella tukiasema voi itse päättää, minkä antennin avulla tai mihin suuntaan tukiasema jatkaa signaalin lähettämistä.

4. Patenttivaatimuksen 1 mukainen menetelmä, t u n n e t t u siitä, että tukiasemien lähettämiä signaaleja vahvistetaan vahvistimilla (121), ja me-

netelmässä lähetysantenniksi valitaan antenni, joka on kytkettynä vahvistimeen, jolla on pienin kuormitus.

5. Patenttivaatimuksen 1 mukainen menetelmä, tunnettu siitä, että tukiasemien lähettämiä signaaleja vahvistetaan vahvistimien (121) avulla ennen lähettämistä, ja menetelmässä tehdään valintapäätös vahvistimien kuormitustilanteen perusteella.

6. Patenttivaatimuksen 1 tai 2 mukainen menetelmä, tunnettu siitä, että mikäli tilaajapäätelaitteen (200) vastaanottaman signaalin laatu on alimman hyväksyttävän laatutason alapuolella, lähetetään tieto edellä mainitun signaalin laadusta tukiasemalle, joka tiedon saatuaan keskeyttää huonolaatuisen signaalin lähettämisen.

7. Patenttivaatimuksen 1 mukainen menetelmä, tunnettu siitä, että lähetetään signaalia tilaajapäätelaitteelle (200) keilojen avulla, ja lopullinen päätös tukiasemassa käytettävästä lähetysantennista, lähetyssuunnasta tai keilasta tehdään tukiasemassa (100).

8. Patenttivaatimuksen 2 mukainen menetelmä, tunnettu siitä, että lähetetään signaalia tilaajapäätelaitteelle keilojen avulla, ja lopullinen päätös tukiasemassa käytettävästä lähetysantennista, lähetyssuunnasta tai keilasta tehdään tilaajapäätelaitteessa (200).

9. Patenttivaatimuksen 1 mukainen menetelmä, tunnettu siitä, että valitaan tukiaseman lähetyskeila, joka aiheuttaa vähiten interferenssiä, ja tehdään valintapäätös tukiasemassa (100).

10. Patenttivaatimuksen 2 mukainen menetelmä, tunnettu siitä, että valitaan tukiaseman lähetyskeila, joka aiheuttaa vähiten interferenssiä, ja tehdään valintapäätös tilaajapäätelaitteessa (200).

11. Radiojärjestelmä, joka käsittää ainakin yhden tilaajapäätelaitteen (200) ja ainakin yhden tukiaseman (100), joka käsittää antennin (140, 141), jonka avulla tukiasema lähettää signaaleja tilaajapäätelaitteelle, tunnettu siitä, että

tilaajapäätelaite käsittää mittausvälineen (230), joka määrittää tilaajapäätelaitteen vastaanottamien signaalien laadukkuuden vertaamalla vastaanotettuja signaaleja ainakin yhteen signaalin laadun kynnystasoon,

tilaajapäätelaite (200) lähettää kynnyksen ylittäneen signaalin lähettäneelle tukiasemalle tiedon antenneista, joiden avulla kynnyksen ylittänyt signaali lähetettiin, tai tiedon lähetyssuunnista, joista kynnyksen ylittänyt signaali vastaanotettiin,

tukiasema (100) käsittää välineen (102), joka valitsee kynnyksen ylittäneiden signaaleiden lähettäneistä antenneista (140, 141) antennin tai antennit, jotka jatkavat signaalin lähettämistä mainitulle tilaajapäätelaitteelle (200), tai väline (102) valitsee kynnyksen ylittäneiden signaalin lähetyssuunnista lähetyssuunnan tai lähetyssuunnat, joihin tukiasema jatkaa signaalin lähettämistä.

12. Radiojärjestelmä, joka käsittää ainakin yhden tilaajapäätelaitteen (200) ja ainakin yhden tukiaseman (100), joka käsittää antennin (140, 141), jonka avulla tukiasema lähettää signaaleja tilaajapäätelaitteelle, t u n n e t t u siitä, että

tilaajapäätelaite (200) käsittää mittausvälineen (230), joka määrittää tilaajapäätelaitteen vastaanottamien signaalien laadukkuuden vertaamalla vastaanotettuja signaaleja ainakin yhteen signaalin laadun kynnystasoon,

ainoastaan yhden signaalin ylittäessä kynnyksen, tilaajapäätelaite (200) lähettää kynnyksen ylittäneen signaalin lähettäneelle tukiasemalle (100) komennon käyttää signaalin lähettämisessä mainitulle tilaajapäätelaitteelle sitä antennia, jonka avulla tukiasema lähetti kynnyksen ylittäneen signaalin, tai sitä lähetyssuuntaa, johon kynnyksen ylittänyt signaali lähetettiin.

13. Patenttivaatimuksen 11 mukainen radiojärjestelmä, t u n n e t t u siitä, että useamman signaalin laadun ollessa hyväksyttävissä olevien tasojen välissä, tilaajapäätelaite (200) lähettää tukiasemalle tiedon, joka perusteella tukiasema voi itse päättää, minkä antennin (140, 141) avulla tai mihin suuntaan tukiasema jatkaa signaalin lähettämistä.

14. Patenttivaatimuksen 11 mukainen radiojärjestelmä, t u n n e t t u siitä, että tukiasema käsittää vahvistimia (121), jotka vahvistavat signaaleja ennen signaalien lähettämistä, ja väline (102) valitsee tukiaseman lähetysantenniksi antennin tai antennit, jotka on kytkettynä vahvistimeen, jolla on pienin kuormitus.

15. Patenttivaatimuksen 11 mukainen radiojärjestelmä, t u n n e t t u siitä, että tukiasema käsittää vahvistimia (121), jotka vahvistavat signaaleja ennen signaalien lähettämistä, ja väline (102) tekee valintapäätöksen vahvistimien (121) kuormitustilanteen perusteella.

16. Patenttivaatimuksen 11 tai 12 mukainen radiojärjestelmä, t u n n e t t u siitä, että mikäli tilaajapäätelaitteen vastaanottaman signaalin laatu on alimman hyväksyttävän laatutason alapuolella, tilaajapäätelaite (200) lähettää tiedon edellä mainitun signaalin laadusta tukiasemalle, joka tiedon

saatuaan keskeyttää signaalin lähettämisen sillä antennilla, jonka lähettämä signaali alitti kynnyksen.

17. Patenttivaatimuksen 11 mukainen radiojärjestelmä, t u n n e t t u siitä, että tukiasema (100) lähettää signaalia tilaajapäätelaitteelle (200) keilojen avulla, ja lopullisen päätöksen tukiasemassa käytettävästä lähetysantennista, lähetyssuunnasta tai keilasta tehdään tukiasemassa (100).

18. Patenttivaatimuksen 12 mukainen radiojärjestelmä, t u n n e t t u siitä, että tukiasema (100) lähettää signaalia tilaajapäätelaitteelle (200) keilojen avulla, ja lopullinen päätös tukiasemassa (100) käytettävästä lähetysantennista, lähetyssuunnasta tai keilasta tehdään tilaajapäätelaitteessa (200).

19. Patenttivaatimuksen 11 mukainen radiojärjestelmä, t u n n e t t u siitä, että tukiasema käsittää välineen (102), joka valitsee tukiaseman lähetyskeilaksi vähiten interferenssiä aiheuttavan lähetyskeilan.

20. Patenttivaatimuksen 12 mukainen radiojärjestelmä, t u n n e t t u siitä, että tilaajapäätelaite käsittää välineen (202), joka valitsee tukiaseman lähetyskeilaksi vähiten interferenssiä aiheuttavan lähetyskeilan.

(57) Tiivistelmä

Keksinnön kohteena on tiedonsiirtomenetelmä ja radiojärjestelmä, joka käsittää ainakin yhden tilaajapäätelaitteen (200) ja ainakin yhden tukiaseman (100), joka käsittää antennin (140, 141), jonka avulla tukiasema lähettää signaaleja tilaajapäätelaitteelle. Tilaajapäätelaite (200) käsittää mittausvälineen (230), joka määrittää tilaajapäätelaitteen vastaanottamien signaalien laadukkuuden vertaamalla vastaanotettuja signaaleja ainakin yhteen signaalin laadun kynnystasoon. Ainoastaan yhden signaalin ylittäessä kynnyksen, tilaajapäätelaite (200) lähettää kynnyksen ylittäneen signaalin lähettäneelle tukiasemalle (100) komennon käyttää signaalin lähettämisessä mainitulle tilaajapäätelaitteelle sitä antennia, jonka avulla tukiasema lähetti kynnyksen ylittäneen signaalin, tai sitä lähetyssuuntaa, johon kynnyksen ylittänyt signaali lähetettiin.
(Kuvio 1)